Mobile applications for chronic disease self-management:

building a bridge for behavior change

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Laurea University of Applied Sciences **Abstract**
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One of the biggest challenges in the future of healthcare is the rising prevalence of chronic, non-communicable diseases. In high-income countries seven out of ten leading risk factor causes of death are caused by the way people eat, drink or move. Health behavior patterns are considered to account for 40 % of early mortality. If nothing changes, from 2011 until 2030 the cost of chronic disease in the whole world will be 47 trillion dollars. It is clear that chronic disease care needs to change. Today people with chronic disease spend less than 0,1 % of their time yearly in direct contact with healthcare and guidance. The rest of the time they are under the influence of family, colleagues, acquaintances, media and all the conflicting information from them.

Digital elements are emerging in healthcare. Some of these digital elements emerging are mobile applications. Of all the people in Finland, 70 % own a smartphone. These devices are often in the proximity of their owner; in a pocket or a purse, making them easy and fast to use for various purposes. This is why they can also prove to be useful tools for personal healthcare and chronic disease self-management support, for example for recording diet and exercise related values as well as various disease specific values like blood glucose or blood pressure measurements. They also enable two-way interaction with healthcare professionals and patients in their everyday life. This requires well designed applications that affect the patient's health behavior and are tempting to use. According to research, this is not always the case.

This thesis explores the field of chronic disease self-management, mobile applications intended for it, and how they implement known behavior change enhancing features. The purpose of this thesis is to create a new, multiprofessional behavior change intervention tool. This is done by first systematically investigating and quantifying currently available mobile applications suitable for multiple chronic disease self-management, and describing their current usefulness in how they aim to change patient's behavior and maintain it using the Behavior Change Technique taxonomy by Michie et al. and the Gamification taxonomy by Robinson and Bellotti. Secondly, a new framework is created building upon existing information, experience and theory by the principles of constructive research approach using also features from autoethnographic approach.

The results impart that the studied applications do not utilize these taxonomies nearly as well as they could. In general, less than 10 % of the possible behavior change techniques were used, and less than 15 % of the possible gamification features were used. This indicates the need for better designed applications that take these features into account. To help in this process, BC-TIP, "the Behavior Change Techniques Intervention Process" framework was developed. This framework will provide visual and narrative guidance amongst the techniques making them easier to be used by professionals from various disciplines, like healthcare and mobile application design.

Keywords: chronic disease, self-management, mobile application, health behavior, behavior change techniques, gamification, health promotion, eHealth, mHealth

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Mobiilisovelluksia kroonisten sairauksien itsehallintaan: silta käyttäytymisen muuttamiseksi

Vuosi 2015 Sivumäärä 95

Yksi suurimmista terveydenhuollon haasteista tulevaisuudessa on kroonisten sairauksien lisääntyminen. Korkean tulotason maissa seitsemän kymmenestä kuolleisuuden riskitekijästä on seurausta siitä, miten ihmiset syövät, juovat tai liikkuvat. Terveyskäyttäytymisen arvioidaan selittävän 40 % ennenaikaisesta kuolleisuudesta. Jos tilanne ei muutu, vuosien 2011 ja 2030 välillä kroonisten sairauksien kustannukset koko maailmassa ovat 47 triljoonaa dollaria. On selvää, että kroonisten sairauksien hoidon tulee muuttua. Nykyään kroonisia sairauksia sairastavat viettävät alle 0,1 % ajastaan vuosittain suorassa kontaktissa terveydenhuoltoon ja ohjaukseen. Loput ajasta he viettävät perheensä, kollegoidensa, tuttaviensa, median ja näiltä tulevan ristiriitaisen tiedon parissa.

Digitaaliset elementit ovat yleistymässä terveydenhuollossa. Mobiilisovellukset ovat yksi näistä elementeistä. Jo 70 % Suomen väestöstä omistaa älypuhelimen. Nämä laitteet ovat usein käyttäjänsä välittömässä läheisyydessä; taskussa tai laukussa ne ovat helposti ja nopeasti käytettävissä eri tarkoituksiin. Siitä syystä ne voivat osoittautua hyödyllisiksi työkaluiksi henkilökohtaisessa terveydenhoidossa ja kroonisten sairauksien omahoidossa, kuten ruokavalioon ja liikuntasuorituksiin liittyvien asioiden kirjaamisessa tai eri sairauksiin liittyvien arvojen, kuten verensokerin tai verenpaineen seurannassa. Ne mahdollistavat myös vuorovaikutuksen terveydenhuollon ammattilaisten ja potilaiden välillä heidän jokapäiväisessä elämässään. Tämä vaatii hyvin suunniteltuja sovelluksia, jotka vaikuttavat terveyskäyttäytymiseen ja ovat houkuttelevia käyttää. Tutkimusten mukaan näin ei aina ole.

Tämä opinnäytetyö tutkii kroonisten sairauksien omahoidon kenttää, siinä käytettäviä mobiilisovelluksia ja sitä, miten ne hyödyntävät tunnettuja käyttäytymistä muokkaavia tekijöitä. Opinnäytetyön tarkoituksena on luoda uusi, käyttäytymisen muutosta tukeva työkalu moniammatilliseen käyttöön. Tämän saavuttamiseksi tutkitaan ja kvantifioidaan ensiksi nykyisiä, kroonisten sairauksien omahoitoon tarkoitettuja mobiilisovelluksia, ja kuvataan niiden hyödynnettävyyttä potilaan käyttäytymisen muuttamiseen ja ylläpitämiseen hyödyntäen Michien käyttäytymisen muuttamisen tekniikoiden taksonomiaa sekä Robinsonin ja Bellottin pelillistämistaksonomiaa. Seuraavaksi luodaan uusi viitekehys, joka perustuu olemassa olevaan tietoon, kokemuksiin ja teoriaan konstruktiivisella tutkimusotteella, käyttäen myös autoetnografisen tutkimusotteen piirteitä.

Tulosten perusteella tutkitut sovellukset eivät hyödynnä näitä taksonomioita läheskään niin hyvin kuin voisivat. Vähemmän kuin 10 % mahdollisista käyttäytymisen muuttamisen tekniikoista ja vähemmän kuin 15 % mahdollisista pelillistämispiirteistä oli käytetty. Tämä osoittaa selvän tarpeen paremmin suunnitelluille sovelluksille, jotka ottavat nämä tekniikat ja piirteet enemmän huomioon. Tämän työn helpottamiseksi kehitettiin BC-TIP, “the Behavior Change Techniques Intervention Process” eli käyttäytymisen muuttamisen tekniikoiden interventioprosessi – viitekehys. Tämä kehys tarjoaa visuaalisen ja narratiivisen ohjeistuksen näiden tekniikoiden käyttöön, jolloin eri ammattiryhmien, kuten terveydenhuollon ja sovellussuunnittelun edustajien, on helpompi käyttää niitä omiin tarkoituksiinsa.

Avainsanat: krooniset taudit, omahoito, mobiilisovellukset, terveyskäyttäytyminen, käyttäytymisen muuttamisen tekniikat, pelillistäminen, terveyden edistäminen, eTerveys, mTerveys

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“It may just mean that the best way to cut the ever-increasing costs of health care around the world will be to provide cheap smartphones with Internet service to those who otherwise could not afford to buy them.”
- Eric Topol, The Patient Will See You Now: The Future of Medicine is in Your Hands

“Mobile phones will soon become the most important platform for changing human behavior. . . . Nothing can stop this revolution." - BJ Fogg

1 Introduction

Intervention can be defined as any act to enhance patient outcomes. It is something each and every nurse and healthcare professional does every day. Even though everyday encounters with patients are seldom perceived as an intervention per se, every discussion by itself or accompanied by some measurement is an intervention. It depends on each professional, how this opportunity is used. Sometimes these situations result in great motivational insights in both parties, and sometimes they result in misunderstanding, anger, and frustration. As a result, sometimes the health behavior of a patient is changed; sometimes it is the healthcare professional whose behavior needs changing. Nevertheless, these personal encounters are a big part of traditional healthcare.

Digital elements are emerging in healthcare. The change is slow and in most parts driven by forces from outside healthcare; technology companies, start-ups innovating new tools, governments and of course patients and citizens demanding better – and more modern – care. It is hard to comprehend that it is possible to file tax returns entirely digitally but for reporting blood pressure or blood glucose measurements, filling a diary manually, arranging free from work and visiting health care facility in person is needed. In the light of every encounter being also a possible health intervention, this is understandable. All personal encounters, however, in reality do not result in health behavior change. Sometimes a majority of encounters is spent in interpreting the patient's handwriting, choosing the right cord for this blood glucose monitor to get the information downloaded to computer, and trying to gather a clear understanding of the whole big picture. As a result, there may be no time left for the real discussion, motivation and support.

Some of these digital elements emerging are mobile applications. Of all the people in Finland, 70 % owns a smartphone (TNS Gallup 2014). This amount insinuates a good potential for reaching as many people as possible, which is one of the main components of effective health promotion programs. These devices very often are also in the proximity of their owner; in a pocket or a purse, making them easy and fast to use for various purposes. This is why they can also prove to be useful tools for personal healthcare and chronic disease self-management support, for example for recording diet and exercise related values as well as various disease specific values like blood glucose or blood pressure measurements. When these measurements can be recorded immediately, it diminishes the chance for information skewing or forgetting.

In real life, the mere existence or availability of a smartphone and mobile application do not guarantee the use of them or the quality of the information delivered. Especially if these mobile applications are intended for supporting chronic disease self-management, they need

to be well designed for that purpose; trustworthy, reliable and focusing on changing health behaviors. Previous research has found that for example weight management related mobile applications do not utilize features of behavior change theories very well (Azar, Lesser, Laing, Stephens, Aurora, Burke & Palaniappan 2013, 586). Therefore, there is a need to find out if that is a problem with mobile applications for chronic disease self-management too. This thesis originates from these before mentioned needs.

This thesis, as a development process, uses features of the autoethnographic research approach while not being an autoethnographic research. The ontological basis of autoethnography is the assumption of reality being always multifaceted. The context and culture are always present in a researcher's experience, which is part of the research. (Peterson 2015, 226-227.) This approach is less used in nursing research, however emerging as a method. One of the core values of the International Council of Nurses is innovativeness which includes being transformational and solution focused (ICN 2015). This thesis is my effort to comply with that. I have been a nurse for almost 15 years and while also being a midwife, genetic nurse and a public health nurse, I have seen various aspects and angles of healthcare. Prior to nursing I worked as an information services secretary, which probably explains my preference to use information and new information related services as effectively as possible in the context of nursing. My interest for new tools to practice nursing also stems from my previous time of working as a consult and a project manager in a startup company developing a mobile application for healthcare. These experiences provide me a broad understanding of the field investigated in this thesis.

During this thesis process I have visited numerous events organized by the Finnish Funding Agency for Innovation, the Finnish Innovation Fund Sitra and other stakeholders. These events all focused on health related technologies, innovation and the future of healthcare. However, people attending these events were mainly from the previously mentioned organizations, research organizations, private companies, start-ups, government officials and sometimes politicians. There were very few healthcare professionals present and in some occasion I was nearly the only one. There were ventures and projects being masterminded about the future of Finnish healthcare without sufficient amount of healthcare professionals participating and in my mind this was, and is, a very worrisome situation. At this year's Finnish Nursing Conference, the chair of the Finnish Nurses Association in her opening remarks called for large-scale and broad vocational competence, stating that technology is an essential part of nursing. To have that kind of technology really needed in healthcare, healthcare professionals have to be part of planning them. These personal experiences provide the cultural context to which this thesis builds upon.

The working life partner for this developmental thesis is a start-up company, whose main purpose is to create and develop mobile services and applications for chronic disease self-management. They are intended to be used in the interactive collaboration of both the patient and her care team for the empowerment of the patient. There is an ongoing need to improve the quality and the content of health related mobile applications. There is also a need for mobile applications with real potential to change health related behavior in an engaging way. The wish from the working life partner is to get an easily understandable tool to implement these features into mobile applications.

To achieve that, this thesis explores the field of chronic disease self-management and support, mobile applications intended for those actions, and how they implement known behavior change enhancing features. The interest also lies in investigating how to utilize these behavioral aspects effectively. For that, this thesis will attempt to construct a framework for better understanding of the behavior change features by the principles of constructive research approach. This framework will hopefully help both healthcare professionals and mobile application developers; healthcare professionals by providing them a new tool for various interventions and mobile application developers by providing them a tool to better understand the possibilities and challenges in designing for health behavior change.

2 Background for the thesis

One of the biggest challenges in the future of healthcare is the rising prevalence of chronic diseases, also called non-communicable diseases. The incidence and mortality have risen particularly in developing countries lately (WHO 2013, 7). In 2007, the European Union published a White Paper in which it acknowledged the worsening trend of poor diets and low physical activity and their part in increasing level of chronic diseases. Among these diseases are cardiovascular disease, type 2 diabetes, stroke, certain cancers and even some mental health conditions. (Commission of the European Communities 2007, 2.) Although extensive actions have been commenced since to correct the situation, the trend is still troublesome in many aspects compared to communicable diseases.

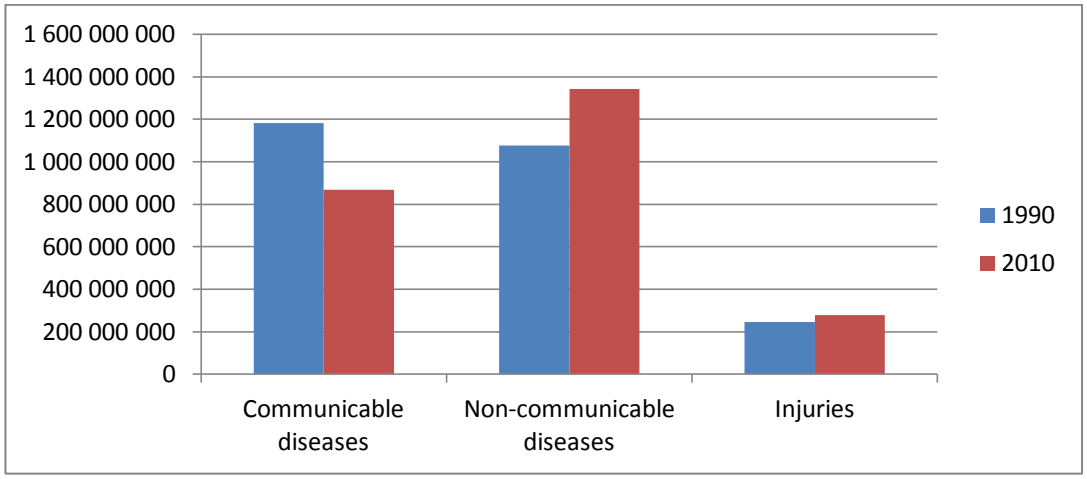


Figure 1: Global disability-adjusted life years (DALYs[1]) in general (adapted from Murray, C. J. L. et al. 2012)

In high-income countries seven out of ten leading risk factor causes of death are caused by the way people eat, drink or move and the numbers are very alike in other parts of the world too (WHO 2009, 11). These factors are high blood pressure, overweight and obesity, physical inactivity, high blood glucose, high cholesterol, low fruit and vegetable intake and alcohol use. Adding tobacco use to the list sums up the top four behavioral risk factors that are behind most chronic diseases.

	Tobacco Use	Unhealthy Diets	Physical Inactivity	Harmful Use of Alcohol	Obesity	Environment	Genetics
Cardiovascular Disease	☑	☑	☑	☑	☑	☑	☑
Diabetes	☑	☑	☑	☑	☑	☑	☑
Cancer	☑	☑	☑	☑	☑	☑	☑
Chronic Respiratory	☑				☑	☑	☑
Mental Illness	☑	☑	☑	☑	☑	☑	☑
Bone & Joint Diseases	☑	☑	☑	☑	☑	☑	☑
Oral Diseases	☑	☑		☑	☑	☑	☑
Vision Loss/ Blindness	☑	☑			☑	☑	☑
Hearing Loss/ Deafness						☑	☑

Figure 2: "Top four" chronic diseases and risk factors adapted from WHO (University of Waterloo n.d.)

[1] DALYs are the sum of two components: years of life lost due to premature mortality (YLLs) and years lived with disability (YLDs). DALYs count how many healthy life years are missed because of impairment, non-fatal illness or death.They can be seen as an absolute measure of health loss. (Murray, C. J. L. et al. 2012.)

There is reasonable data suggesting that by leading a healthy life a person can avoid many of these diseases. It was shown in a cohort of almost 25 000 European people that by never smoking, keeping body mass index (BMI) under 30, exercising 3,5 hours or more per week and maintaining a healthy diet the risk of major chronic diseases is reduced by 78 percent. It is, however, unfortunate that only less than one in ten people in this same study met the criteria for all four healthy traits. It is notable that keeping BMI under 30 alone reduced the risk more than any of the other traits alone. (Ford, Bergmann, Kröger, Schienkiewitz, Weikert & Boeing 2009, 1357-1358.) In the light of the statistics and studies it is clear, that in addition to previous efforts also new efforts should be pursued in personal, healthcare, national and multinational levels to reduce these risk factors and especially obesity.

At European level, the White Paper from EU (2007, 3-9) laid the framework to be used tackling these chronic diseases and the risk factors leading to them. The paper called for:

1. principles of action
    - which should be targeted at the root causes, aimed at all government policy areas also engaging private sector and society, required from wide area of private actors such food industry and local level actors like schools, and finally monitored carefully
2. taking a partnership approach
    - developing partnerships at European level and strengthening local networks
3. policy coherence at the community level
    - better informed consumers, making the healthy option available, encouraging physical activity, prioritizing certain groups and settings, developing the evidence base and developing monitoring systems.

Today many other guidelines have been implemented. At European level, one of the most important ones is the third EU Health Program 2014-2020. It updates the whole health related framework in Europe. In addition to financial aspects, it calls for the need for innovation in health as public health policy, not only in technology but also "the field of public health interventions, prevention strategies, and health system management. The organization and provision of health services and medical care, including health promotion and disease prevention interventions, has the potential to improve public health outcomes". (European Commission 2014, 2.)

The 2014 EU Summit on Chronic Diseases made a very clear statement about proceeding with the battle against chronic disease. The summit called for recognizing health as a value and investment to the future. It also brought up the utmost importance of modern prevention as a key and the importance of the broad involvement of the whole civic society. The summit

clearly stated that modern methods should be used like eHealth, mHealth and other IT solutions for better out-of-hospital activities and services. The main importance lies in the empowerment of citizens and having them take responsibility for their health. (European Commission 2014, 2-3.)

3 Chronic disease management in today's world

Prevention of chronic disease should be the priority in every country. However, as previously stated, the prevalence of the non-communicable disease is high and has increased while infectious disease prevalence has decreased. Not only has the total number of non-communicable disease increased but there are certain chronic diseases that represent a very distressing trend as seen in figure 3.

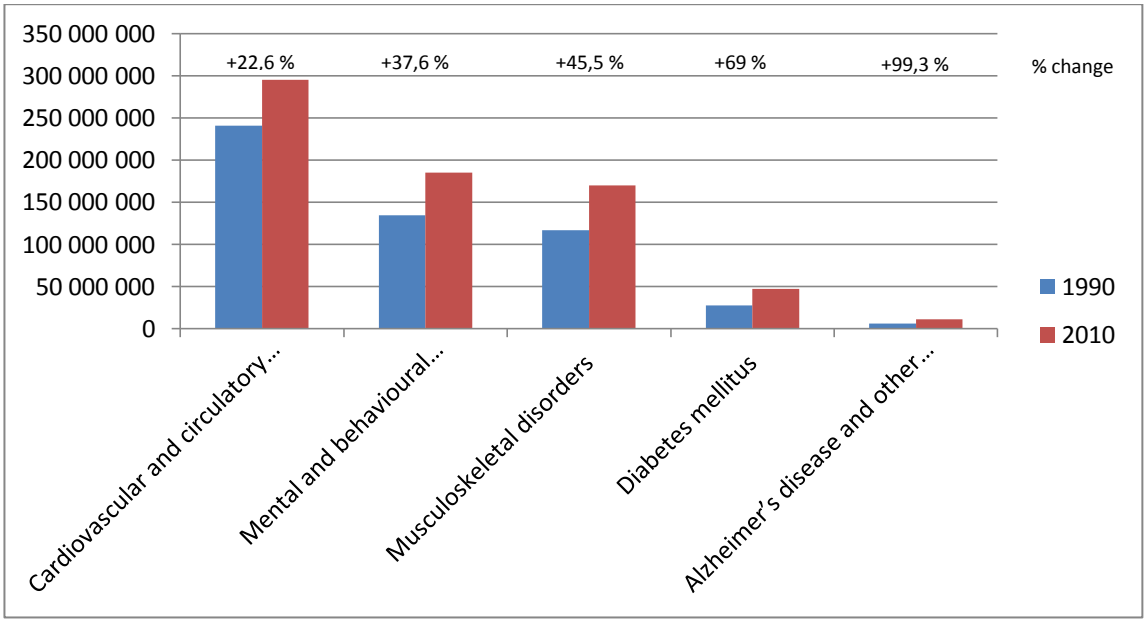


Figure 3: Global disability-adjusted life years (DALYs*) and change by various disease groups (adapted from Murray, C. J. L. 2012)

The rate of the increase in for example Alzheimer's disease and diabetes is alarming. As discussed before, most of the risk factors for chronic disease are same. In addition to age and genetics, the risk factors for Alzheimer's disease with strong evidence are physical inactivity, hypertension, obesity, smoking, depression, hypercholesterolemia, metabolic syndrome, and diabetes, especially in midlife. It is estimated that at least 25 percent of cases could be prevented by focusing on the elimination of the risk factors. It has also been estimated that the cost of dementia worldwide is 604 billion dollars annually (WHO 2012, 28-30.)

A recent Finnish randomized controlled study of 1260 people, who were 60-77 years old with physical and cognitive risk factors, showed that by active intervention it is possible to reach

significant positive results. There were beneficial effects on both cognitive and physical aspects, like executive functioning, processing speed, BMI and physical activity. The intervention program consisted of tailored individual diets, active physical exercise training, cognitive training by psychologists with individual computer-based training and management of vascular risk factors by nurse and doctor supervision. (Ngandu, Lehtisalo, Solomon, Levälahti, Ahtiluoto, Antikainen, Bäckman, Hänninen, Jula, Laatikainen, Lindström, Mangialasche, Paajanen, Pajala, Peltonen, Rauramaa, Stigsdotter-Neely, Strandberg, Tuomilehto, Soininen & Kivipelto 2015, 2-3, 6-7.)

Research (e.g. Ford et al. 2009, Ngandu et al. 2015) shows that by focusing on promoting healthy lifestyle choices and active engagement it is possible to maintain health and prevent disease progression. Health promotion is the guiding principle of every healthcare professional's work. It has been acknowledged since 1978 Alma-Ata Declaration that health is a fundamental human right, and that people have "the right and duty to participate" in the planning and implementation of their healthcare (WHO 1978, 1). The Ottawa Charter for Health Promotion later in 1986 continued the theme and defined health promotion as "the process of enabling people to increase control over, and to improve, their health" (WHO 2009, 1). Therefore, it has been a focal point since the beginning to empower people also to take control of their own health.

3.1 Chronic Care Model

In addition to health promotion, there is also a need to focus on prevention. Prevention can be described as prevention of disease or prevention of disease getting worse. Healthcare professionals practice primary prevention, secondary prevention and tertiary prevention that are concepts originating from 1940's when public health pioneers Hugh Leavell and E. Guerney Clark created them. Primary prevention seeks to prevent diseases before they happen so this is mostly linked with health promotion methods. Secondary prevention is aimed at screening actual risk factors and identifying illnesses at an early stage so they can be promptly treated to prevent disease progress. Tertiary prevention is focused on treating the patient, preventing possible handicap from worsening and rehabilitation. (Davidson 2011, 1-2.) It is not always easy to differentiate these stages of prevention as they are somewhat overlapping.

As a way to prevent progression of chronic diseases and improve care Edward Wagner and his colleagues (1998) created the Chronic Care Model. The development of this model was based on the fact that chronic care cannot be provided the same way as primary care if it is supposed to be good and cost effective. The model focuses on improving chronic care outcomes by:

1. incentivizing changes in the care delivery systems and having well-developed processes
2. providing behavioral self-management support to patients prioritizing patient confidence and skills
3. modifying team function and practice towards the needs of the patients
4. providing guidelines for healthcare professionals and increasing collaboration between them
5. improving information systems, their usage and developing disease registries

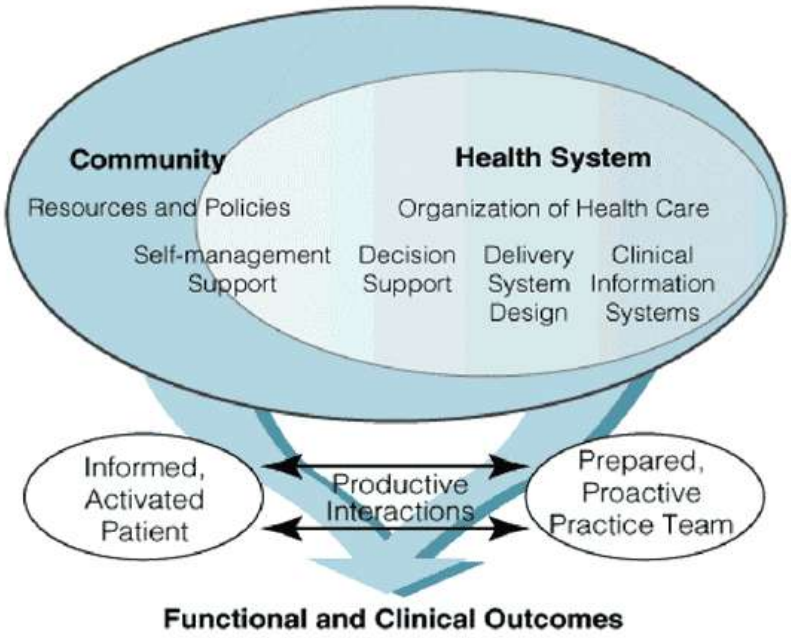


Figure 4: Model for improvement of chronic illness care (Wagner 1998, 3)

Studies of the Chronic Care Model have been proven to be effective in improving care, even with a single component like self-management. The model has been researched mainly in the care of diabetes, congestive heart failure and asthma. More studies have shown reductions in the cost of care, especially as reduced days in hospital or fewer visits to the emergency services, than others which have not. (Bodenheimer, Wagner & Grumbach 2002, 1910-1911.) A recent Cochrane review also indicates that personalized care planning slightly improves certain components of physical and psychological health improving self-management capabilities simultaneously. Best results are attained when care planning is integrated with the patient's routine care and when interventions are comprehensive. (Coultier, Entwistle, Eccles, Ryan, Shepperd & Perera 2015, 3.)

3.2 Intervention recommendations

A recent review by Horodyska, Luszczynska, van den Berg, Hendriksen, Roos, De Bourdeaudhuij & Brug (2015) studied the characteristics of various interventions towards healthy eating and physical activity. The review was conducted applying the WHO framework so that intervention characteristics, evaluation and implementation best practices were searched from both previous reviews and stakeholder documents. The main good characteristics for interventions were numerous. The use of theory and specific behavior change techniques with self-monitoring and self-management strategies were seen important, tailored to the well specified target behavior. The target audience needs to be well defined, their needs identified and especially if focusing on children, the whole family involved. A beneficial approach would take all dimensions into account; physical, social, individual and personal factors. Individual contacts and their intensity with personnel providing the intervention should be specified in advance, and the capabilities of the personnel addressed. (Horodyska et al. 2015, 7.)

For the content of the intervention, numerous issues should be considered. First, the duration should be well specified. Second, a form of delivery could be for instance web-based, short messages or self-guided with or without human contact. Third, distinguishable strategies and elements to prompt healthy diet and physical activity should be implemented and fourth, clarity should be a priority in both the content and the aims. This clarity should include all the manuals and protocols so that they can be implemented right now and in the future, too. (Horodyska et al. 2015, 7.)

There is good evidence in favor of using a human contact in interventions, despite the increasing use of digital equipment. Kivelä, Elo, Kyngäs and Kääriäinen (2014, 156) reviewed research on health coaching on patients with chronic disease, and found that it is an effective mean for self-efficacy building, changing lifestyle behaviours and improving mental and physical health. Another research by Willard-Grace, Chen, Hessler, DeVore, Prado, Bodenheimer and Thom (2015, 134) found that a year long coaching by medical assistants improved patients' control of hemoglobin A1c and LDL, but not blood pressure.

Despite the evidence for successful interventions, there is also some lack of evidence about their outcomes. All tailored interventions for chronic disease management have not proved better outcomes than conventional care. However, criticism has been raised about the quality of the research, as many studies implicate less than optimal research design that compromises the results and makes comparisons difficult. Cost and resource utilization are often neglected in the studies, and adequately powered studies are needed. (Radhakrishnan 2012, 508.) A Cochrane review identified quality issues also being prevalent in studies about medi-

cation adherence interventions. The studies with the best quality, clinical outcomes and adherence, are usually complex and use frequent interaction with patients. Recommendations are that interventions to improve adherence should last as long as the medication, so the best way is to integrate it into normal care processes. (Nieuwlaat, Wilczynski, Navarro, Hobson, Jeffery, Keepanasseril, Agoritsas, Mistry, Iorio, Jack, Sivaramalingam, Iserman, Mustafa, Jedraszewski, Cotoi & Haynes 2014, 17.)

3.3 eHealth adoption for self-management?

Medical care has traditionally, in general, focused on the 15 minutes of giving information, instructions and medication for patients with chronic disease and then leaving them alone for the rest of the year. Next year the same thing will repeat itself but maybe with a change of medication. This situation can go on for 10 to 20 years until the patient has a heart attack or a stroke with a price tag of 20 000 euros. What would happen if the power situation would be changed totally around? Instead of giving instructions healthcare would give patients information, tools, ongoing support and consultations. Change of perspective would, of course, be difficult for both parties at first but eventually most patients will understand that they are in charge of their own bodies and health. This change in healthcare is not a new thing as it has been anticipated for at least two decades now (Holman & Lorig 2004, 119).

Self-management is not an easy concept to define as it addresses so many sides of human life. Barlow, Wright, Sheasby, Turner and Hainsworth (2002, 178) underline the abilities of people. Self-management is about being able to live with a chronic disease by managing the symptoms and treatment, and by being able to monitor the condition while maintaining a good enough life. All this includes both the physical and psychosocial aspects of life as well as the emotional and cognitive aspects. The ability to address necessary lifestyle changes is essential too. (Barlow et al. 2002, 178.) Patients with chronic disease have implied their need for individual and ongoing self-management support as their disease may progress or fluctuate (Houtum van, Rijken, Heijmans & Groenewegen 2013, 629). Healthcare professionals want changes to their everyday work, to be able to support patients' self-management. They want to have programs based on behavioral strategies, clearer goals and better communication with patients put at the center of care (Higgins, Murphy, Worcester & Daffey 2011, 80).

Chronic disease self-management programs have been proven to work. Stanford School of Medicine created and evaluated a program for over 1000 chronic disease patients and found out that once a week program during six weeks helped to improve various components of patients' overall health. It resulted in fewer hospitalizations while being also cost effective (Stanford Patient Education 2015). There is also increasing evidence that using modern mHealth tools for monitoring chronic disease on ongoing basis has positive effects on patient

adherence towards their chronic disease management (Hamine, Gerth-Guyette, Faulx, Green & Ginsburg 2015). Patients have reported the use of two-way mobile applications to increase their sense of security at home, knowing that they are not forgotten by professionals. Communication needs of patients do not end while they are at home. Mobile applications which can help to manage all aspects of the illness are needed, as well as trained nurses or other professionals for whom "health-related smartphone apps could serve as the therapist's extended arm into the daily life of the patients". (Wang, Wang, Wei, Yao, Yuan, Shan & Yuan 2014, 571-582).

Empowering patients concerning their control with chronic disease should be accepted by all, but, unfortunately, there still are critics towards this approach. There are claims that the patients who would need to take better care of themselves are older and socially less active, so they don't know how to use these new methods so why bother (IMS Institute for Healthcare Informatics 2014, 2). There are also some concerns about the possible information flow from patients 24/7 as healthcare has no way of dealing with it yet. There are clearly many issues that remain unsolved so far, but that is not a reason to ignore the issues. If anything, it should encourage us to study more new possibilities and develop viable new processes.

Innovations in healthcare IT sector are numerous. They are usually focusing on new technologies, drugs and therapies (Macdonnel & Darzi 2013, 653). Healthcare consumers are also demanding better services and the control of their own healthcare data (e.g.Terveystieto.me) and that is leading to new kinds of services and innovations in the search for better consumer rights and cost savings. This all combines in a theory of care transition, which focuses on dealing with rising healthcare cost, shift from medical paternalism to managed consumerism, care transition between lay people and professionals as well as between acute care and long time care and finally adopting policies emphasizing patient focus (Bury & Taylor 2008, 216-207).

On the other hand, healthcare innovations are criticized for creating new healthcare needs and more expensive solutions for them, so the net cost is higher than before. Macdonnel and Darzi (2013, 655) consider that one culprit in this situation is the fact that healthcare innovators have forgotten that innovations should succeed in one critical thing: reducing labor expenditure that is one of the biggest expenditures within healthcare industry. Then what is labor-saving in healthcare? Macdonnel and Darzi (2013, 656-657) present three different categories: labor-saving technologies including mobile devices and applications, workforce innovation which includes new professional roles and processes and last but not least, increasing patient skills and adapting self-service approaches.

New information and communication technology is indeed going to renew healthcare shortly. There has been some progress over the last years, but because of the various different, incompatible ICT systems with scattered and isolated purchasing methods, the progress has not been as fast as it could have been. All healthcare professionals are not comfortable using ICT systems and it still shows at various healthcare organizations as ambivalence or straight forward opposing attitude. It is clear that technology alone does not solve anything if it is only some new program or software without carefully planned part of the workflow. A whole new paradigm shift is needed. Unless the care processes themselves inside healthcare are carefully remodeled to apply and implement the new ICT and eHealth systems, those systems will not be effective.

Today there are almost 20 000 hits in PubMed when searching with the term eHealth. A quick browse through the first page of the results reveals that eHealth in these studies can stand for telemedicine, mHealth using mobile applications, telehealth, video consultation, personal health records and cloud computing. The scope is wide. Today eHealth is often used as a synonym for digital health or connected health, depending on which country and which organization. European Union defines eHealth as a set of tools and services, which can improve healthcare in various stages of the care like prevention, diagnosis, monitoring and treatment with the aid of information and communication technology (European Commission 2015).

The benefits of eHealth are thought to be in the creation of more personalized, targeted, effective and accurate care. It is also possible that it will facilitate equality and access to services and information. (European Commission 2012, 4-5.) One of the largest advantages of eHealth is that it serves as a base for the next step of modern healthcare, the personalized healthcare and personalized medicine. Personalized medicine brings the gene or genome data into the equation of healthcare, and there are predictions that it will improve the quality and cost of healthcare a great deal. The challenges eHealth faces are mostly linked to the missing legal frameworks and national strategies, funding and business models, balancing interests and coordinating efforts in addition to lack of awareness and trust among healthcare professionals, patients and citizens. There is also a lack of large-scale evidence of cost effectiveness. (Moen, Hackl, Hofdijk, Van Gemert-Pijnen, Ammenwerth, Nykänen & Hoerbst 2012, en6; European Commission 2012, 5.)

Problem with eHealth, as a relatively new way of managing chronic diseases, has also been the lack of studies showing the efficacy of these interventions. Fortunately, there are ongoing research efforts aimed at this problem. Very interesting results have just been received from a Mayo Clinic research team about the use of digital health interventions towards cardiovascular disease prevention. In their review, they found out that with digital health interventions it was possible to achieve almost 40 % risk reduction in secondary prevention patient groups,

especially in heart failure patients. This is bigger reduction than usually achieved with more conservative measures, like aspirin or statins. Evermore, the benefits are likely the result of better adherence to conventional medication. (Widmer, Collins, Collins, West, Lerman & Lerman 2015, 477.) All this is very important information, as the medication adherence is known to be notoriously inadequate in patients with chronic disease, around 50 % in general (Nieuwlaat et al. 2014, 3).

There is a major healthcare IT related strategy renewal taking place in Finland at the moment. The Ministry of Social Affairs and Health has just published a new strategy to guide the renewal (STM 2015). The Ministry takes quite a strong stand on for example the electronic solutions for patient self-care and communication between health care personnel and patients. Prevention and self-evaluation of health care needs are underlined and the health data originating from the patients will be used to plan and implement care and services. (STM 2015, 10.) This is a big step towards eHealth adoption in the healthcare system and better management of chronic disease, including self-management.

Nationally common efforts are also being made towards the automatization of care processes with the possibility for patients to send self-monitoring data to the use of healthcare professionals through personal health record or some other means. It is, of course, first priority to discuss and create the whole ICT architecture and total framework for combining all aspects of the patient journey. (Self-care and digital value services 2015.) Nevertheless, some worries arise because these plans seem to imply that patients are thought to do computer based self-testing about their risk factors and get automated responses and recommendations how to proceed. It may well be the right way to proceed with some minor problems like common cold or headaches, or screening of chronic disease risk factors and creating recommendations accordingly. Caution should, however, be practiced, because especially considering long-term chronic disease, the support for self-management is of utmost importance and should not be forgotten.

As previously discussed, coaching is an important element in the care of patients with chronic disease (Kivelä et al. 2014). There have been consistent findings about the advantage of health IT systems, which provide means for reporting and monitoring patient self-monitoring data, interpretation of this data against individual treatment plans, adjustments of these plans when necessary, communicating with the patient with individually tailored plans and repeating this all at certain intervals. In other words, a complete feedback loop is essential. (Jimison, Gorman & Woods 2008.) This loop is shown as a part of a bigger picture in a suggested model for the eHealth Chronic Care Model in figure 5 (Gee, Greenwood, Paterniti, Ward & Miller 2015). While studying the reasons why people who have accomplished a web-based eHealth check did not proceed to the subsequent digital eHealth coaching, Karppinen,

Lehto, Oinas-Kukkonen, Pätiälä and Saarelma (2014) found out that despite a positive attitude towards the system, some people found the system not quite as elaborate as it could have been. Many people also revealed their life situation being too complex, like having not enough time, personal capacities or traits to pursue the automated eHealth coaching (Karppinen et al. 2014). It is the job of healthcare professionals and coaches to address these complex situations so they should not be left out of the equation when supporting self-management and behavior change for better health.

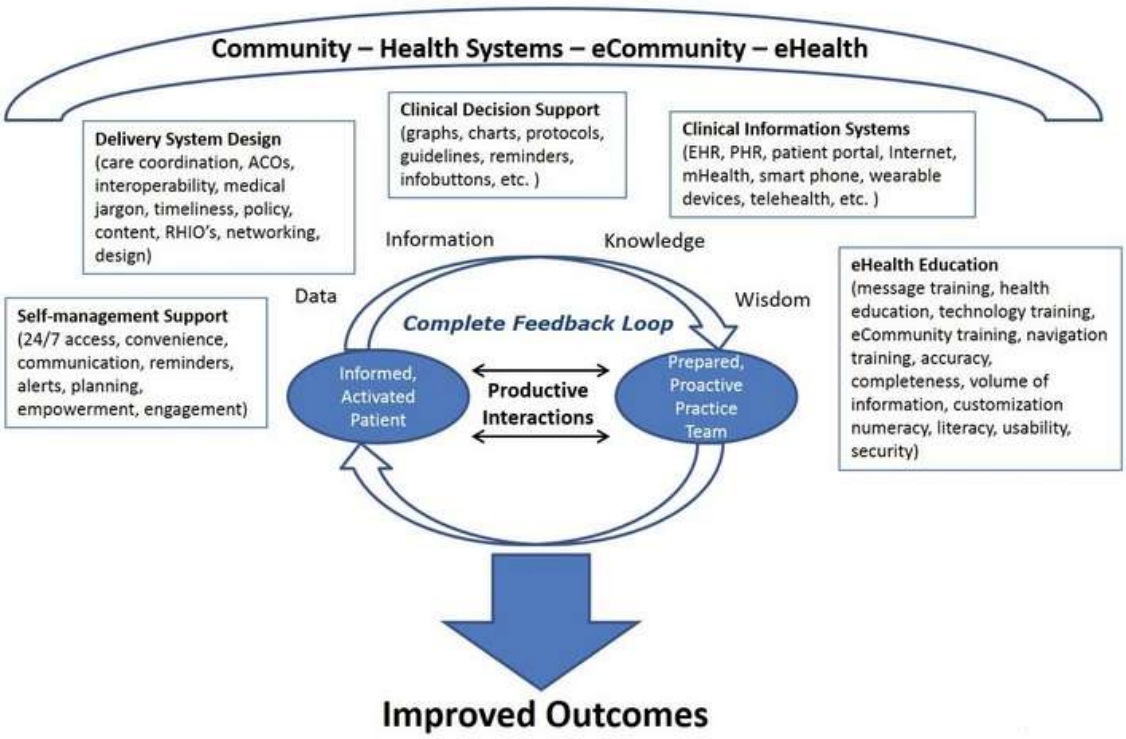


Figure 5: Chronic Care Model enhanced with eHealth (Gee et al. 2015)

4 It's a mobile world

The smartphone penetration in the United States is 64 % (Pew Research Center 2015, 13). In Finland, 70 % of the people own a smartphone (TNS Gallup 2014). Over 75 % of Finnish people between the ages of 16 and 54 use smartphones to access the internet (Statistics Finland 2014). 77 % of people over 65 years own a mobile phone in the United States (Pew Research Center 2014, 4). In that age group 27 % own a smartphone and in the age group 30+ the percentage is 53% (Pew Research Center 2015, 13). In the Netherlands smartphone penetration has nearly doubled in one year rising from 23 % to 43 % in the age group 65+ (Telecompaper 2014). 61 % of Dutch households own a tablet, and almost half of tablet users are over 50 years old (Telecompaper 2015). 27 % of people over 65 own a tablet in the United States (Pew Research Center 2014, 4).

As seen from the numbers of the previous paragraph, the amount of smartphones and other mobile devices is rising all over the world. According to the Statistics of Finland (2014), the use of the internet is still growing mainly in the age group 55+. The number of smartphone penetration varies from 14 % in Indonesia to the United Arab Emirates leading the way with almost 74 % (Wikipedia 2015). Worldwide it is estimated that there are now over one billion smartphones, and numbers are rising especially in India and China. A number of mobile subscriptions is almost seven billion worldwide (Statista 2015). It is clear, that mobile phone or smartphone is the choice of the future when thinking about reaching as many people as possible. Reaching as many people as possible is also one of the aims of health promotion programs.

A mobile application is a type of application software designed originally for the purpose of mobile device use. It is usually individual and small unit of software. (Techopedia n. d.) Some of these applications are called native, which means that they are coded with a specific programming language and can, therefore, be used only in certain operating systems or platforms like Apple's iOS or Google's Android OS. The advantage of these native applications is that they are usually faster and can take advantage of the mobile device's own functionalities like the camera better. There are also other kinds of mobile applications like web applications, which are coded with languages also used in creating websites. All this makes them somewhat easier to create but often slower to use because they use the mobile device's web connections. This thesis will, however not discuss the differences or preferences of these application types.

The use of mobile devices in healthcare is called mHealth. The m in front of health comes from mobile, which leaves room for many kinds of devices, not only phones. mHealth is situated under an umbrella term, which can be digital health or connected health or eHealth like discussed before. An official definition by WHO (2011, 6) includes both medical and public health care that is practiced with the aid of mobile devices like phones, monitoring devices and other wireless devices.

There are many advantages of using smart phone applications for health interventions. A study from England in 2014 revealed that people pick up their smartphone in average 221 times per day (Tecmark 2014). This indicates that smartphones are constantly available so they can be easily accessed. Other advantages are smartphones' abilities to provide feedback, interactivity, adjustability and large reach (Middelweerd, Mollee, van der Wal, Brug & te Velde 2014, 1). These combined with smartphone features like camera, accelerometer, proximity sensor, GPS and microphone provide a great opportunity to create very individual, timely and location-specific health interventions.

These sensing abilities of smartphones could be utilized much more than they are now. There are plans to create mobile applications, which together with the smartphone could detect antecedents of smoking behavior, use algorithms to calculate risk points and then provide personalized, timely interventions in smoking cessation situation (McClernon & Choudhury 2013, 1653). A mobile application does not necessarily need to be that sophisticated to be effective in many ways. Stanford University School of Medicine has recently launched an application, which also collects data for research purposes. The application uses phones' built-in motion sensor to collect data from walk test combined, with the possibility to enter risk factors and get feedback accordingly (White 2015).

At the end of 2014 there were over 2,6 million mobile applications available for downloading in the leading two application stores (appFigures 2015) and it is estimated that there are at least 100 000 mHealth mobile applications in those two stores (research2guidance 2014). Fitness, medical reference, wellness and nutrition applications represent over 70 % of all the health applications. Only 7,2 % of the applications focus on the management of medical conditions and remote monitoring and/or consultation.

Today's trend in health and wellness seems to be wearable health trackers that can track steps taken, pulse, sleep and more variables. The critique has been addressed to the fact that the people who use these are usually healthy, sporty young men and women without any health problems. The people who would need those most are not wearing them for various reasons. (Patel, Ash & Volpp 2015, 459-460.) One of these reasons according to Patel and his colleagues is that they are often used for only a while because the novelty fades away. Engagement is clearly an issue with these wearables and other mHealth related factors. Compliance to chronic care self-management has also been known to be an issue for a long time (e.g. Fielding & Duff 1999, 199), so new ideas are needed to improve both engagement and compliance.

5 Theoretical framework for the thesis

5.1 Behavior change

The term behavior change brings together many different scientific disciplines including psychology, public health and health promotion. Behavioral theorists from psychology have addressed many public health and lifestyle change issues for decades (Leviton 1996, 42). Some of the behavioral change theories and models applied in public health prevention programs originate straight from psychology. Usually the behavior change methods or techniques used in interventions are derived from these theories and models. Behavior change, eliminating harmful habits and behavior like inactivity and replacing them with positive behavior like ex-

ercise, is the most important aspect of chronic disease prevention and management (IOC consensus group 2013).

The health of a person depends on many factors. Some estimates claim (figure 6) that the personal behaviors of people count for nearly half of the estimated determinants of early mortality. It is, therefore, understandable that there is a strong need to focus on these behaviors and change them for better to make improvements in health on both personal and public health levels.

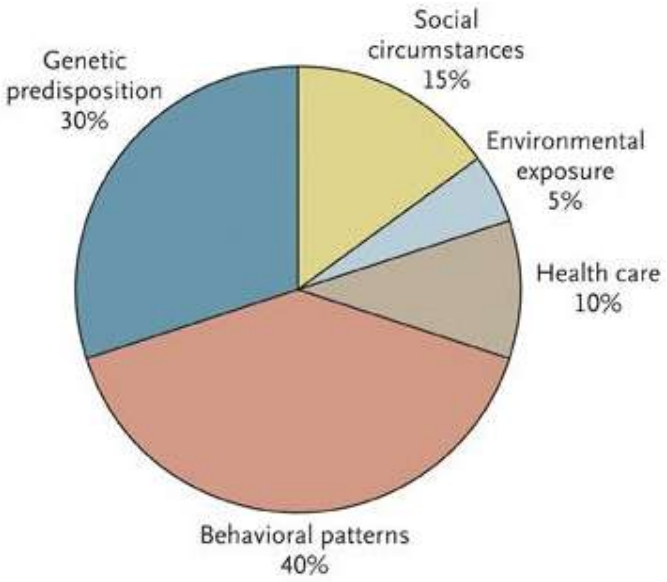


Figure 6: Determinants of health and their contribution to premature death (McGinnis, Williams-Russo & Knickman 2002, 83)

Most people recognize which features of their behavior are unhealthy, but changing behavior is not easy. Several reasons for difficulties in behavior change in the context of chronic disease prevention have been identified. One of them is socioeconomic status, which can include low income and low educational level. People who live alone can be more likely to have unhealthy lifestyle choices. Stressful situations at work or home can make adopting healthy lifestyle harder. Other negative emotions like depression, anxiety and hostility can influence choices. Sometimes advice given can be confusing or too complex. These are some of the many reasons for not adopting healthy lifestyle even though the knowledge is available. (Graham, Atar, Borch-Johnsen, Boysen, Burell, Cifkova, Dallongeville, De Backer, Ebrahim, Gjelsvik, Herrmann-Lingen, Hoes, Humphries, Knapton, Perk, Priori, Pyörälä, Reiner, Ruilope, Sans-Menendez, Scholte Op Reimer, Weissberg, Wood, Yarnell & Zamorano 2007, S20.)

Then how can people be empowered to make healthy choices, take responsibility for their health and by doing so prevent chronic disease or progression of chronic disease? It is known

from many studies that health promotion by health information per se is not necessary effective enough to accomplish lasting positive behavior changes (Horgen & Browner 2002; Robinson, Ruxton & Derbyshire 2014; Fleming & Higgs 2014.) There are various theories and methods that have addressed behavior change, and they will be discussed in the following paragraphs.

5.1.1 Behavior change theories and models

A recent review by Davis, Campbell, Hildon, Hobbs and Michie (2014) searched for theories, which have been used in published behavior change research since 1977. This review specifically dealt with research aimed at individual behavior change, not group behavior change. The four most often implemented theories accounted for 64 percent of all the cases. These theories were Transtheoretical/Stages of change model by Prochaska (1983), Theory of planned behavior by Ajzen (1985), Social cognitive theory of Bandura (1986) and Information-motivation-behavioural (IMB) skills model by Fischer (1992). The next four theories resulted in 32 percent of all the cases and they were Health belief model by Rosenstock (1966), Self-determination theory by Deci (2000), Health action process approach by Schwarzer (1992) and Social learning theory by Miller (1941). (Davis et al. 2014, 13.)

The reviewers discuss these theories in some depth. The reason for the increased use of previously mentioned theories lies in the fact that most of them are quite old, and so they have been available for research purposes for a longer time. The reviewers, however, critique that all this does not necessarily make them superior compared to other theories. There are some theories, like the most used Transtheoretical/Stages of change model, which has been criticised by some instances (eg. Adams & White 2005, 242), for not addressing the complexity of behavior change. Some theories, like Health belief model, focus on the initiation of the change but not on the maintenance part of the change (Ryan 2009, 4) or the emotional side of behavior (Champion & Skinner 2008, 62). Another reason for the lesser use of other theories may well be that people are not aware of the full range of potential theories. (Davis et al. 2014, 13, 15-16.) All of these previously mentioned theories have their own merits. It should be however remembered, that certain theories fit certain contexts better than others, and it is always imperative to consider the intervention as a whole to be able to choose the right theoretical combination.

Some relevant theories are the previously mentioned Self-determination theory and Social cognitive theory, and one of the newer theories is the PRIME theory of motivation by West (2006). Needs and motivations are very important aspects of behavior change. The Self-determination theory focuses on three innate needs: competence, autonomy and relatedness (Ryan & Deci 2000, 68). Zuckerman and Gal-Oz (2014, 1707-1708) refer to Self-determination

theory as they state that these needs act as the determinants of motivation, and if they are satisfied it enhances intrinsic motivation, but they can also diminish it if being out of balance. According to Bandura's Social Cognitive theory the elements of an effective prevention program include information about health risks and benefits of other choices, developing necessary social and self-management skills into preventive practices, building a resilient sense of efficacy for difficult times and creating social support for good changes (Bandura 2004, 158).

The PRIME theory is one of the newer theories, and it addresses the complexity of behavior quite well. A professor of health psychology Robert West published this theory in 2006 in his book "Theory of Addiction". As the title implies the theory was originally created around addiction and behavior, but it has since evolved to concern behavior change in a larger perspective. Figure 7 illustrates the main components of the theory. The central ideas of the theory originate from the concept that our behavior is driven by wants and needs, the motives. West describes wants being satisfaction or anticipated pleasure and needs being the avoidance or anticipated relief from discomfort, which can be mental or physical. These wants and needs are influenced by our identity and our beliefs of good and bad which balance with internal and external stimuli. People always act according to the strongest motivation of the moment, evaluating and planning each component of it. (West n. d.) Understanding the drivers of the behavior is a key to creating supportive behavior change interventions.

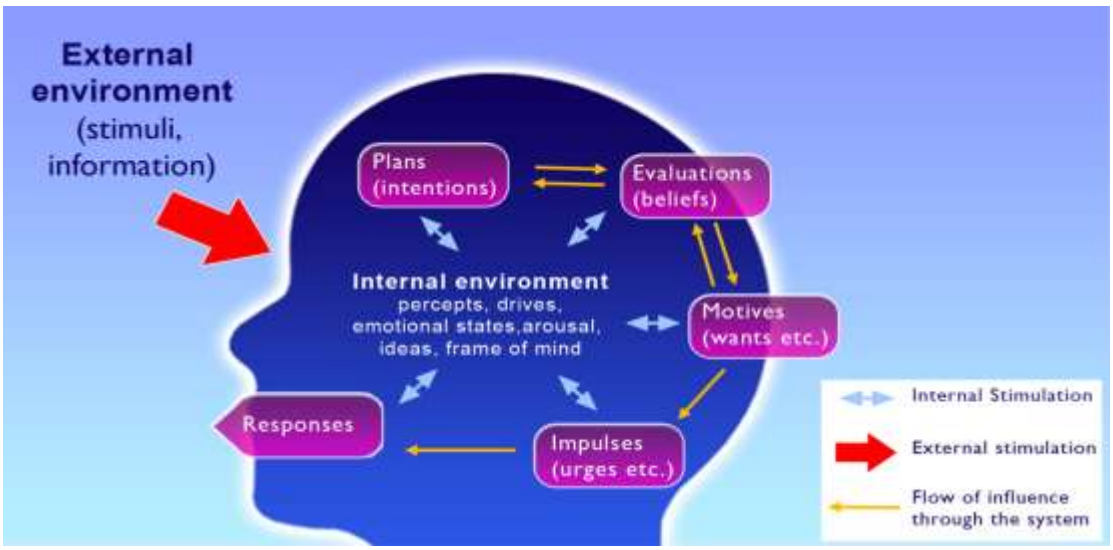


Figure 7: PRIME theory of motivation (West n. d.)

The PRIME theory intertwines with a COM-B model of behavior attempting to create a framework for behavior change interventions. The COM-B model of behavior states that three conditions must occur for certain behavior to happen; the capability to perform it, the opportunity to do it and the motivation to do it, hence the acronym C(apability)

O(pportunity) M(otivation) equals B(ehavior). (Michie, van Stralen & West 2011, 4). Motivation alone is not enough; there has to be also the way. A psychologist, BJ Fogg (2009) describes almost the same analogy in his Behavioral Model. This model is aimed at designing various persuasive technologies. It is based on the fact that in order to have behavior change there needs to be motivation, ability and trigger; they also need to happen at the same time.

In today's world, there are many theories that can be used for different interventions. The problem often is in choosing the right one or right ones. Interestingly, during the last decade there has been scientific discussion challenging the relevance of some of these theories. The critique is that while the basic assumption in science should be that theories are tested, modified accordingly and/or developed to new theories, this seems not to be the case in the health behavior theory literature. Comparisons are rare in health behavior theory literature, and while the new theory is being created the old theories are not discarded. The problem with health behavior theory seems to be that many theories have basically the same constructs but use different terminology. (Noar & Zimmerman 2005, 276-277.) Therefore many theories overlap, which makes their interpretation and usage harder. As an attempt to take advantage of the common constructs of these theories, a Behavior Change Technique Taxonomy was created.

5.1.2 Behavior Change Technique (BCT) Taxonomy v1

The BCT taxonomy is the creation of professor Susan Michie and her colleagues from the University College London, England. Abrahams and Michie (1998, 381) originally identified several behavior change techniques from the work of researchers like Prochaska, DiClemente and Norcross (1992), Hardeman, Griffin, Johnston, Kinmonth and Warehman (2000) and Conn, Valentine and Harris (2002). Abrahams and Michie, however, recognized that those techniques were mixed with other aspects like theoretical approaches and delivery methods. They acknowledged the need to create a common set of theory-linked techniques to be used in various interventions in different behavioral domains. This way future intervention could establish the common terminology and thereby improve the methodological validity, comparability and much-needed replicability. (Abrahams & Michie 2008, 379, 381, 385.) This taxonomy has been developed for over a decade, and the main part of the work has been funded by the UK's Medical Research Council. Over 400 professionals and policymakers internationally have been part of this work by developing it, evaluating it and creating a training program for it. (BCT Taxonomy 2015.)

There is an exhausting list of theories behind this taxonomy. As previously mentioned in the paragraph of theories, all theories have their own merits. Nevertheless, no single theory can provide a total framework for interventions that can be intended for various subject areas

and populations. For various health behavior change interventions, the researchers have also created the behavior change wheel (BCW), which has been created out of the existing 19 frameworks of behavior change from literature. The COM-B model is the basis of this wheel and it addresses various policy categories and intervention functions. (Michie, van Stralen & West 2011, 7.)

Behavior change techniques can be described as the smallest components or active ingredients, which can be used alone or in combination to alter behavior in replicable way (Michie, Richardson, Johnston, Abraham, Francis, Hardeman, Eccles, Cane & Wood 2013, 4). The taxonomy consists of 93 different behavior techniques, which are structured hierarchically under 16 clusters for easier usability of the taxonomy. An example of a cluster is "Comparison of behavior". Under this cluster, there are three behavior change techniques "demonstration of behavior, social comparison and information about others' approval". (Michie et al. 2013, 17-18.) Each of these techniques is provided with a definition as well as examples. A comprehensive list of all behavior change techniques from this taxonomy can be found in appendix 1.

Clusters	**Examples of BCTs**
Goals and planning	Goal setting, action planning, behavioral contract
Feedback and monitoring	Feedback on behavior, self-monitoring of behavior, biofeedback
Social support	Social support (practical), social support (emotional)
Shaping knowledge	Instruction on how to perform the behavior, information about antecedents
Natural consequences	Information about health consequences, monitoring of emotional consequences
Comparison of behavior	Demonstration of the behavior, social comparison, information about others' approval
Associations	Prompts/cues, satiation, associative learning
Repetition and substitution	Behavior substitution, habit formation, overcorrection
Comparison of outcomes	Credible source, pros and cons, comparative imaging of future outcomes
Reward and threat	Material incentive, social reward

Regulation	Pharmacological support, conserving mental resources, paradoxical instructions
Antecedents	Restructuring the physical environment, distraction, body changes
Identity	Identification of self as role model, valued self-identity
Scheduled consequences	Behavior cost, rewarding completion
Self-belief	Verbal persuasion about capability, focus on past success
Covert learning	Imaginary reward, vicarious consequences

Table 1: Some examples of Behavior change techniques (Michie 2013)

These behavior change techniques can be used to replicate accurately previous studies, as mentioned before. They can also be used to evaluate previous intervention research systematically. Developing and implementing new interventions using these techniques will help to plan more comprehensive intervention designs, which in the future will help to identify the most effective combinations for certain situations. (Michie et al. 2013, 6-7.) Dusseldorp, van Genugten, van Buuren, Verheijden and van Empelen (2014, 1536) reviewed over 100 studies on behavior change and found that the use of providing information about consequences, providing information about behavior-health link with prompting follow-up resulted in most effective behavior change. Another good combination was to provide information about behavior-health link and prompt intention formation. All this clearly shows how important it is to address the need to change by providing the behavior-health link, which could turn into intrinsic motivation.

In their meta-analysis about using the internet to promote health behavior change Webb, Joseph, Yardley and Michie (2010) found a positive correlation with the use of psychological theory, behavior change techniques and interaction with the participants. In this analysis automated tailored feedback did not provide as good as results as did the possibility to interact with an advisor. Interestingly, the behavior change techniques about stress management, communication skills training, relapse prevention and social comparison yielded the best results of all, after the use of text messages in interventions. (Webb et al. 2010.) A study of 239 newly diagnosed type 2 diabetics found that the use of 11 or more behavior change techniques in one intervention improved the likelihood of a reduction in body mass index. The behavior change techniques found to be most effective in this study were goal setting, goal review and social support. (Hankonen, Sutton, Prevost, Simmons, Griffin, Kinmonth & Hardeman 2015, 14.)

It is also possible to create mobile applications that are based on theory and utilize behavior change techniques. Payne, Lister, West and Bernhardt (2015) conducted a systematic review of research on the use of mobile applications in health interventions. They found that all studied applications had some component of theory in them. The studies included in this analysis used applications for increasing physical activity, weight loss, diabetes and mental health interventions. All the applications for mental health had constructs of behavior change in them, but very few of the diabetes applications were designed to include them purposefully. Self-monitoring and social support were used most prominently. In general, the results for efficacy of these interventions were fairly good. The researchers, however, called for more studies with enough power and the use of applications, which utilize more behavior change possibilities in a single application. (Payne et al. 2015.)

A study of top 20 paid and free mobile applications for physical activity and diet recognized on average 8,1 behavior change techniques in these applications with slightly more techniques in paid applications. Mostly used techniques were providing instructions, setting graded tasks, self-monitoring, demonstrating behavior and social comparison (Direito, Pfaeffli Dale, Shields, Dobson, Whittaker & Maddison 2014, 4.) Even fewer behavior change techniques have been found in applications for alcohol consumption reduction, the mean number being 2,46 there (Crane, Garnett, Brown, West & Michie 2015, 6). In the light of knowing that there might be a connection between changed behavior and the number of behavior change techniques in an intervention, there is certainly room for more behavior change techniques in these mobile applications.

5.2 Behavior change maintenance

A person who has successfully managed to change her behavior, in one way or the other, needs ongoing support especially if the change has been hard. Often, however, people are left quite alone after congratulations from the healthcare professionals about the accomplished change. One of the behavior change theories addressing behavior change maintenance is the Transtheoretical/Stages of change theory. According to this theory the maintenance phase lasts from six months to five years, and during that time it is important to make sure that there are relationships that help the maintenance, reinforcement of the healthy behavior and removing cues for the unhealthy behavior, to name a few (Prochaska, Redding & Evers 2008, 100, 102, 105).

Not all behavior change interventions address behavior change maintenance. It has been calculated that 35 percent of interventions focusing on physical activity and diet reported maintenance outcomes. In those studies reporting maintenance, 72 percent reported achieving it. Those interventions that lasted long enough (> 24 weeks) included face-to-face con-

tact, used more than six intervention strategies and follow-up prompts were more likely to succeed in achieving maintenance. (Fjeldsoe, Neuhaus, Winkler & Eakin 2011, 106.)
Some of the problems of the behavior change maintenance research and healthcare scene include the lack of addressing multiple behaviors at the same time and forgetting environmental inputs to behavior. The lack of developmental perspective like the role of epigenetics, the fragmentation of the research and the overall economics of healthcare are also often neglected. There is a need for multidisciplinary work that takes into account research from various disciplines like neurobiology, psychology, imaging and computer science. New methodologies, including new methods, are needed. (NIH 2009.)

The cost issues are also compelling; the economic state of the world is distressing, and it is probably not going to improve in the near future. Personal appointments are expensive. Often patients with chronic disease meet both a doctor and a nurse on their visit to the health care facility. They sometimes also meet with other personnel, like nutrition therapists or podiatrists. Some visits, naturally, are necessary in person. However, some of the contacts might be possible to handle digitally. One approach to engaging patients with chronic disease is a simple text message-based program reminding patients to report their home measurements, get laboratory tests when due and get medication refills when due. This approach has been quite successful in engaging well about 60 % of the mostly 50-59 years old female Latin Americans (Moore, Fischer, Steele, Durfee, Ginosar, Rice-Peterson, Berschling & Davidson 2014, 67). This approach is quite straightforward, but requires interoperability with electronic medical record system, laboratory IT system and pharmacy IT system.

Engagement and activation of chronic disease patients are important. Improved activation results in lower hospitalization and emergency unit usage (Kinney, Lemon, Person, Pagoto & Saczynski 2015, 550). One way to do this is to have patients monitoring their condition at home, which will also provide health care new knowledge not currently available to them. While studying the acceptance of digital remote monitoring in older adults, Giger, Pope, Vogt, Gutierrez, Newland, Lemke and Lawler (2015, 181) found that the longer these approximately 76-year-old women with multimorbidity used the equipment, the more they appreciated it. It is important to understand that digital health systems can be utilized with an older population as well, but the education and guidance need to be implemented accordingly. In addition to monitoring, the engagement behavior framework (EBF) recommended actions for patients are following treatment plans agreed together with care provider, including diet, exercise and medication, and being aware of personal health targets and acting accordingly (Gruman, Holmes Rovner, French, Jeffress, Sofaer, Shaller & Prager 2010, 352).

A smartphone, with built-in sensors and cameras, equipped with a suitable mobile application, could be one solution for interactive care and behavior change maintenance. There are some mobile applications, which can import data from various wearable sensors, or the data can come through a third party like Apple's HealthKit or Google's Fit. Having a mobile application in one's smartphone, however, does not guarantee the use of it. Some statistics indicate that 15 % of health and fitness applications are opened only once (Localytics 2014). Healthcare professionals cannot just give patients tools to use in isolation, but they need to co-create interactive services and programs to support self-management. There is an ongoing need to invent ways to keep patients engaged in their own care no matter the medium for it. Some mobile applications use game design elements to keep users coming back to use the application more. To explore this perspective further, gamification is addressed because games are popular among many people from various social and age groups to the extent of compulsive gaming. If these elements can help people wanting to use mobile applications for chronic disease management they can be a valuable addition to the design.

5.2.1 Gamification

The term gamification is derived from the concept of gaming. In healthcare, gamification is seen as a new potential way of better engaging patients in their own care. It can also be seen as a tool for behavior change maintenance. Merriam-Webster (2015) defines gaming as "the practice of gambling, playing games that simulate actual conditions or playing video games". Gaming is a big industry topping even movie industry with game sales of 76 billion dollars per year worldwide (Galarneau 2014). Some misperceptions exist about gaming being only the favorite pastime of teenagers. Interesting statistics from the United States however reveal that over 74 % of gamers are adults, 44 % of them are female and their average age is 35. There are 35 % of people who use their smartphones for gaming. The games most often played with mobile devices are social and puzzle type of games. (Entertainment Software Association 2015, 3, 5.)

Hunicke, LeBlanc and Zubek (2004) have created a framework for games, which gives a clear picture of the elements needed to create good games. The MDA framework consists of mechanics, which are the "verbs" of the games; dynamics represent the "grammar" as the big picture of how components should work together and the aesthetics, which create the framework around the mechanics and dynamics. The aesthetics can be described as the narrative, challenge, discovery or fantasy; really the reason to play in the first place. (Hunicke, LeBlanc & Zubek 2004)

Much referenced definition of gamification is Deterding, Dixon, Khaled and Nackes' (2011, n.p.) definition "the use of game design elements in non-game contexts". Gamification as a

concept may be novel in theory but in practice that is not the case. Gamification has been used everywhere, especially in marketing, for quite a while disguised as bonus points and reward cards from various shops and other enterprises. The concept gaming, however, is usually discussed more in the proximity of video games, online games and mobile games. There is an ongoing debate whether gamifying everyday concepts is useful. Much of this debate has to do with the fact that most of the concepts used are not well defined and concepts like game elements, game mechanics and game dynamics are used almost interchangeably. Seaborn and Fels (2014, 17-18) cite Zimmerman (2011), Bogost (2011a) and Robertson (2010) in their critique of taking only some game elements like leaderboards or badges to use and thinking they alone provide enough engagement to gamify non-game contexts. This is clearly a problem, because as the MDA framework implies, there also needs to be the reason, the aesthetics, for participating. Robson, Plangger, Kietzmann, McCarthy and Pitt (2015, 3) suggest a new framework for gamification adapted from the MDA framework. The new MDE framework supersedes the aesthetics and replaces it with emotions because it better describes the anticipation that precedes engagement.

Even though the science of whether gamification works as a tool for behavior change in everyday situations is scarce, it is an approach worth investigating. Some of the rules games implement are derived straight from psychology. Hamari, Koivisto and Sarsa (2014, 3026, 3029) connect gamification to motivation, psychological outcomes and eventually behavior outcomes. They reviewed 24 studies from various disciplines, like education, health and work and found that gamification seems to work and yield positive results. There is also some evidence that the mere idea of a game, presented maybe only with a game board and nothing else, may change the perspective of the task at hand to something more fun and intrinsically motivating and enjoyable. This may well be more of a case of framing than it is of game mechanics. (Lieberoth 2015, 240.)

Gamification is about persuasion, just like health behavior change. There should be a story, a goal and means to achieve the goal. The designers have certain design elements that they will use to make gamified experiences. Cugelman (2013, 2) offers seven persuasive strategies gamification designers can use based on multiple gamification professionals' ideas (figure 8). There is a striking resemblance in the first two of these strategies and health behavior change strategies. However, in the healthcare system there is certainly less feedback, reinforcement, comparing progress and social connectivity not to mention the complete lack of playfulness. A relatively easy way to achieve the rest might be the use of well-designed, maybe gamified mobile applications in combination with health coaching.

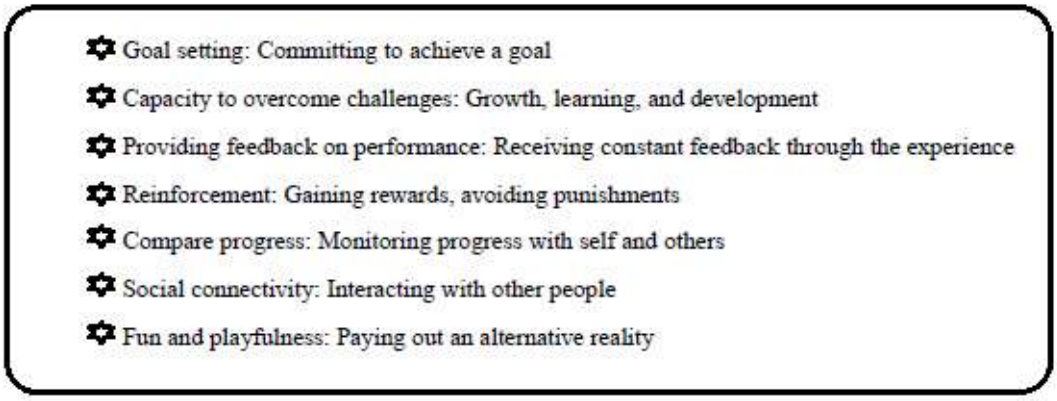


Figure 8: Seven persuasive strategies for gamification (Cugelman 2013, 2)

When people think rationally they know that in order to stay healthy or prevent the progression of the chronic disease they already have, they need to maintain a healthy lifestyle and adhere to their treatment regime. The goals are usually defined together with the healthcare provider and wealth of information is given. People's wants and needs, however, interact with external reality all the time, like the PRIME theory describes. No matter how good intentions are, they are often not enough. Goals and plans are a good starting point, but the execution of those plans needs continuation; continuous reinforcement and connectivity.

Motivation is usually needed to commitment, but there are two kinds of motivations. First, there is intrinsic motivation which is the innate inclination to explore, learn and achieve. No outer trigger is needed while striving towards a personally most fulfilling goal. Children with their endless curiosity are a prime example of intrinsic motivation when pursuing some activity itself results in satisfaction. Some of the actions providing intrinsic motivation are optimal challenges and positive feedback, as well as rewards that promote feelings of competence. The other motivation type is extrinsic motivation. It is motivation from outside or performing some activity to achieve something with that activity. (Ryan & Deci 2000, 70-71.) In gamification discussion, there has been some debate whether extrinsic motivation items from the game world, like points and badges, provide motivation in gamification. This discussion is warranted, because sometimes a reward, like money, can straightforward demotivate people, especially if people are already intrinsically motivated. Ryan and Deci (2000, 71) however remind that people can be intrinsically motivated only in some, genuinely personally appealing activities. Most tasks people need to engage are not, so there is a need to find ways to find other solutions to motivate people in the tasks they are necessarily not so keen on accomplishing. They suggest that extrinsic motivation, which supports people's competence, autonomy and relatedness, might be the answer. (Ryan & Deci 2000, 74.)

The Behavioral Model for persuasive technologies suggests different approaches for different situations. The original idea in this model is that for behavior to change, motivation, ability

and trigger need to occur simultaneously. However, sometimes motivation may be low. In this case if the ability is high enough and there is a trigger, behavior can change. Likewise, if the ability is low, high enough motivation can be enough to spark change. The crucial thing is the trigger. Even if motivation and ability are high, the lack of trigger can result in behavior not changing. (Fogg 2009.) In designing gamified tools, like mobile applications, these principles are important to embed into the system to achieve continuous usage. The social media especially utilizes the idea of trigger well; the auditory or visual signal from the smartphone demonstrating a new message from Facebook or some other service gets many people opening the phone even in the middle of something else.

Gamification in the context of chronic disease management is not an easy concept. The current care models, as discussed previously, don't focus on interactivity and continuous feedback, let alone relatedness or social components due to the delicate and private nature of personal health related information. Gamification and games are however more and more entering the chronic disease management scene. Kamel Boulos, Gammon, Dixon, MacRury, Fergusson, Miranda Rodrigues , Mourinho Baptista & Yang (2015) describe three different games to boost self-efficacy in managing type 1 and type 2 diabetes. These games are very different from each other, underlining the importance of defining target audience as newly diagnosed children with diabetes type 1 need motivation and enhanced coping skills, when on the other hand older patients with type 2 diabetes may need more social peer-to-peer support for compliance with lifestyle issues. A recent randomized controlled study evaluating social support and gamification revealed that both of these features increased physical activity, empowerment and decreased the use of healthcare services in over 50 years old patients with rheumatoid arthritis (Allam, Kostova, Nakamoto & Schulz 2015).

Games, especially video and computer games, are known to cause compulsive behavior in some individuals so that they can play for hours at a time. Not all games are addictive nor are all gamers addicted. There are however some features in these games that keep players coming back again and again which are adopted for gamification purposes. Earlier research on digital slot machine game design has revealed some features that casual game designers have taken advantage of. These features are for example various rewards, non-rewards for the frustration value, reinforcement schedules for rewards, 12:1 ratio near misses, skills and competition, some degree of loss of control and the concept of flow. (Harrigan, Collins, Dixon & Fugelsang 2010, 133.)

Some other game and gamification features have been used in previous research by Lister, West, Cannon, Sax & Brodegard (2014). They searched health and fitness mobile applications for these features and the use of behavioral theory. The game elements used in more than 20 percent of the apps were different levels of play, ranks of achievements, competition under

explicit rules, time pressure, leaderboards, feedback from game before and during, parallel communication systems, self-representation with avatars and feedback / reinforcement afterwards, in order from 21 % to over 57 %. The gamification elements used were levels of achievement/rank, leaderboards, competitions/challenges, digital rewards and social or peer pressure, ranking from almost 27 % to 59 % of the applications. From a behavioral theory perspective, almost 97 % of the applications utilized self-monitoring and over 50 % used cognitive strategies, goal setting and promoting self-efficacy, respectively. (Lister et al. 2014, 7.) From these examples, it shows that there are not yet very clearly defined taxonomies for differentiating game elements and gamification elements as the same features can be used in both. From the literature, I have chosen a closer look at one quite comprehensive gamification taxonomy, which is presented in the following paragraph. Compared to other gamification taxonomies, this taxonomy is one of the most versatile ones.

5.2.2 Gamification taxonomy

David Robinson and Victoria Bellotti (2013) present a general framework, taxonomy, of different gamification elements or features that can be used to develop and create gamification into various disciplines. They originally studied why employees did not use their benefits portal as much they could to their interest. They found that the employees lacked the engagement to use the portal hence making it much more difficult to navigate and remember relevant information considering it. As a result the authors, based on their own experience and literature, created the taxonomy of gamification elements that could be used to create a more engaging experience.

The taxonomy is divided into six gamification categories. They provide the main framework. General framing is for providing motivation and context, the “why” for participating. General rules and performance framing creates the basic knowledge of “what” to do and what can be expected. Social features are for interacting with others either within or out of the gamified experience. Incentives in the experience are divided into various intrinsic and extrinsic rewards. Resources and constraints provide the boundaries in the gamified environment. Finally, the feedback and status information provide the users the understanding of their actions and maybe of others, too. The total number of the gamification features is 42. (Robinson & Bellotti 2013.)

The six categories consist of different kinds of elements suggested being used in various combinations. The elements are presented with the information of needing low, medium, high or various engagement levels, thus making it easier for the designers to implement into different kinds of gamified environments. (Robinson & Bellotti 2013.) The complete taxonomy is presented in appendix 2.

6 Research design

6.1 Purpose of the thesis and research questions

The purpose of this thesis is to create a new, multidisciplinary behavior change intervention tool for both healthcare professionals and mobile application developers to aid their development processes. This is first done by systematically investigating currently available mobile applications suitable for multiple chronic disease self-management and describing their current usefulness in how they aim to change patient's behavior and maintain it. Secondly, a new tool is created building upon existing information and theory. The research questions are:

1) What behavior change techniques are used in mobile applications suitable for chronic disease self-management?
2) What gamification taxonomy elements have been used to maintain the change and the use of application?
3) How could behavior change techniques be better utilized in health intervention planning and mobile application development?

All this information will be useful for healthcare organizations as they are adopting mHealth services to be a part of their new processes. There has been some discussion about physicians feeling the pressure to take advantage of these self-management health applications but not knowing which of them are good and which are not. Recent efforts have been made to alleviate this problem. In England the National Health Service (NHS) has established Choices – health apps library in which reviewed health apps are presented (NHS n. d.). There are also private efforts for this matter like HealthTap AppRx, which is a report of physician recommended health apps (HealthTap 2015). A similar approach might be appropriate in Finland, too.

The aim of this thesis is, therefore, to provide a snapshot of the presently available, multipurpose chronic disease self-management mobile applications and describe the level of how they utilize behavior change techniques and gamification features. This thesis presents science-based behavior change techniques and investigates their relationship with health interventions. This is done by creating a new framework. With these actions this thesis also wishes to serve as a stepping stone for healthcare providers in traditional services but also in eHealth and mHealth scene creating new tools and services. There is also a good possibility they will prove to be valuable for health and medical mobile application developers as well.

6.2 Methodological framework for the thesis

This thesis utilizes autoethnographic features to provide context to my professional role in this thesis process. Otherwise, this thesis relies on the constructive research approach. The constructive research approach, developed in business administration and technology research, is a methodology for producing innovative new constructs for real life problems. An important aspect of this approach is, that not only is it intended for solving real life problems, it also provides new contribution to the theoretical base, the discipline. An important feature also is the fact that there is an ongoing discussion between empirical reality and theory. Noteworthy also is, that the empirical intervention of the researcher is strong, contrary to traditional research approach. This naturally creates the requirement, that the researcher possesses deep understanding and expertise of the research phenomenon and deepens them along the research process. The ideal result of the constructive research approach is a construct, which solves the real life problem and contributes to the theory as well. (Lukka 2001; Dodig-Crnkovic 2010, 360, 362-363.)

Constructive research approach bears a resemblance to innovation research and service design. The commonalities are that they all use applicable theories with industrial relevance in order to design practical solutions (Piirainen & Gonzales 2013, 208). The difference, however, lies in the fact that all constructs are not necessarily innovations or services but results of development projects resulting as new systems, models or materials. Methods used in constructive research can vary, and multiple methods are encouraged. (Ojasalo, Moilanen & Ritalahti 2014, 65.) One of the aspects of validity in constructive research approach is testing the created construct. Piirainen and Gonzalez (2013, 211) refer to Lukka (2006) and Kasanen et al. (1993) when they describe that maybe even the only necessary evaluation method for the construct is holistic market test, which should reveal whether the construct can be made to work in real organization. These tests can be weak market tests, which tell whether any business manager, or responsible professionals in other organizations I would imagine, would be willing to apply the construct, and semi-strong market tests, which describe whether the construct is widely adopted in organizations. The strongest market test would show that the organizations or units using the construct manage better than the one's which do not use the construct.

This thesis uses mixed methods; quantified content analysis to gain more knowledge about the real life problem and to test existing theory, as well as service design thinking to guide the creation of the final construct. The content analysis answers the first two research questions. The constructive process proceeds through design thinking that enables the future solution to be visualized, and provides the purposefully tailored building blocks for the foundation

of the construction (Dodig-Crnkovic 2010, 360). It will provide the answer to the third research question.

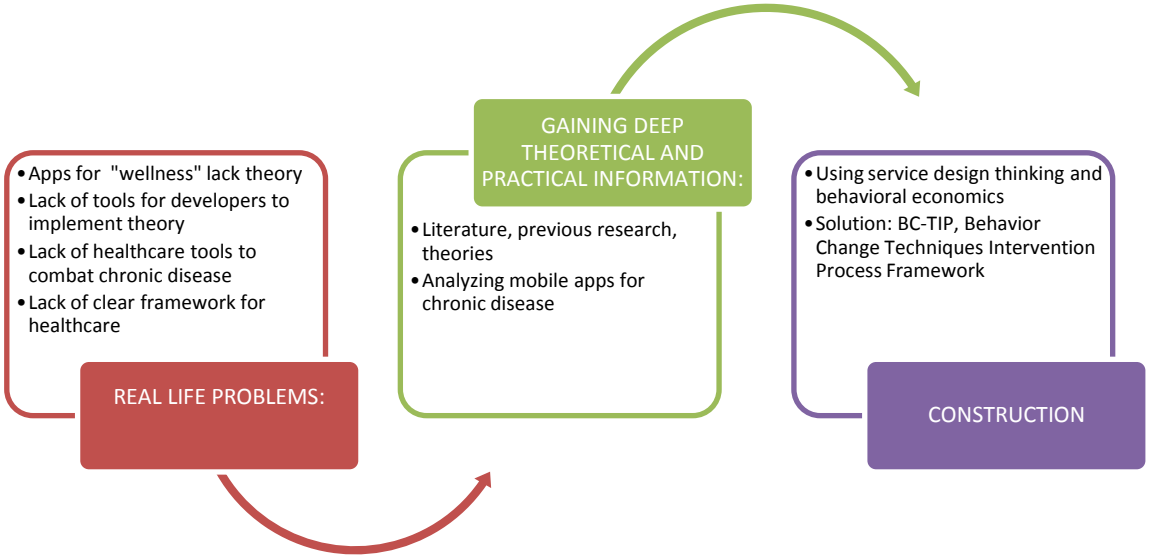


Figure 9: The steps of constructive research approach in this thesis

This thesis, as discussed in the introduction, also uses features of the autoethnographic research approach. The ontological basis of autoethnography is the assumption of reality being always multifaceted. The context and culture are always present in a researcher's experience, which is also part of the research. (Peterson 2015, 226-227.) This provides a different perspective to the phenomena of the society. In autoethnography the researcher is an insider, unlike in traditional research. The scope of autoethnographic research is broad, ranging from very evocative personal narratives to layered accounts, where the author's experience is at focus in addition to the data, analysis and literature. (Ellis 2000, 739; Ellis 2011, 278.) The features adopted in this thesis are closer to the layered accounts type.

My personal experience has shown that healthcare professionals do not really know how to use mobile technology yet in the context of healthcare and therefore remain even overly cautious about it. In addition to this, the behavior change taxonomy by Michie et al. (2013) has not yet been introduced to Finnish healthcare, to my knowledge. Therefore this thesis is a desk study, investigating and bringing these concepts more to common knowledge and alive.

6.3 Mobile application content analysis

6.3.1 Research material and search process

The Finnish Apple iTunes store was used for searching the apps. The reason for this is that even though Google Play app store got ahead of Apple iTunes app store in 2014 with its 1,4 million applications (appFigures 2015), a large part of the applications in these two stores are the same. iTunes is not left far behind with its 1,2 million applications. Previous research on physical activity promoting mobile applications revealed no differences of behavior change techniques in mobile applications between iTunes and Google Play (Middelweerd 2014, 7). Also the fact that I only own an iPad and am doing this research alone was the reason for this approach. The search was done to find all available multipurpose mobile applications that focus on the self-management and self-monitoring of chronic diseases. The search of the available applications was conducted in April 2015. The Power Search function of iTunes was used for this purpose. To find the applications the search terms displayed in table 2 were used.

The purpose of choosing these terms was the attempt to avoid applications aimed specifically at a certain disease like diabetes or high blood pressure. Most people with chronic disease have multiple risk factors so one mobile application per condition may not be suitable for the holistic perspective of self-management. Premature labeling of people could also lead to non-adherence. People with chronic diseases or risk factors for them often have diminished capacities in endurance, so it is inconvenient and time-consuming to use many mobile applications.

Search term	**Results iPhone**	**Results iPad**
Chronic disease	9	4
Metabolic	18	17
Heart health	17	9
Health management	18	10
Disease management	1	1
Self-management	14	9
Self-monitoring	1	0
Health diary	21	7
Disease tracker	1	1
Illness tracker	4	1
Disease monitor	0	0
Illness monitor	0	0
Health tracker	58	25

Health monitor	13	6
Health monitoring	4	1
eHealth	15	9
mHealth	6	4
Prevention	73	40
	273	**144**

Table 2: iTunes search results

Next all application headers were copied and collected to a separate document. iPhone applications and iPad applications were compared to each other and noticed, that there were no iPad applications that did not have a match in the iPhone applications. After that, only the 273 iPhone applications were studied further. Duplicates, foreign language applications, non-healthcare related applications and applications not focusing on humans were removed, which left 196 applications for a closer look. When there were "Lite" and "Pro" versions of the same application, the "Lite" version was chosen, as the "Pro" versions are usually more expensive.

All of the descriptions and screenshots of these applications were opened in iTunes and evaluated for further participation. The detailed inclusion and exclusion criteria are presented in table 3. In this evaluation, all the applications that did not fit inclusion criteria were excluded. Most of the applications excluded at this point were applications for conferences, magazines and other venues, wrong language or purely fitness, diet and weight loss applications. The applications left at this point (41) were all downloaded from iTunes to the iPad to be assessed for further eligibility. The iOS version of the tablet computer was 8.3.

Inclusion criteria	**Exclusion criteria**
Possibility to report health-related measurements and/or monitor health	Addresses only one disease or risk factors of one disease
Can be used for the self-management of chronic diseases or addresses at least three common risk factors (like weight, blood glucose, blood pressure etc)	Applications purely aimed at fitness or diet without the possibility to report any risk factors
Intended mainly for the use of patients	Applications intended solely for healthcare professionals

Both free and fee-based applications	Cost over 20 euro
English or Finnish language	Glossaries or web magazine apps
Can be used exclusively as mobile application	Applications that cannot be loaded to iPad
Can be used by all (gender neutral)	

Table 3: Inclusion and exclusion criteria for the mobile applications

The mobile applications were downloaded to my iPad for better visibility. People with chronic disease are for the most part middle-aged or older generation so tablet computer may well be the choice for them because of the better visibility. All of these applications were informed to be compatible with iPad. Both free and fee-based applications were accepted for comparison as long as within reasonable price range. While downloading and analyzing the original 41 chosen applications, some promising other applications, similar to "gray literature", caught attention and were included in the closer evaluation. Therefore, the total number of applications downloaded was 51.

I explored the chosen applications once downloaded. At this point, seven applications were excluded because they would not work, crashed or had bugs that prevented their use. All of these applications were reported to be iPad compatible so the use of iPad should not be the reason for them not to work. One application was originally reported to be in English, but in reality it was Spanish and excluded at this point. Three applications could be used only for heart rate reporting, one application provided only information, one application was a health quiz, one was meant for certain organizations' health challenge and three could only be used together with external equipment. Three applications did not provide the possibility to report any measurements, one was purely fitness application and three were just one-time risk analysis. Seven applications required either a code from a doctor or a membership of certain wellness facility to be able to use. At this point, 31 applications in total were excluded based on their non-eligibility that left 20 applications for the final analysis.

6.3.2 Data analysis

The 20 remaining applications were carefully explored, one at a time. Each application was initially studied for at least an hour exploring all possible functions, like what can be monitored and what features are included. This exploration produced 10 general functionalities and 22 various measurements. A separate Excel spreadsheet was created and observations

were registered in it. All behavior change techniques and gamification taxonomy features were added in it as a foundation. After the initial familiarization with the applications, they were further analyzed and categorized for the behavior change techniques (93) and gamification features (42) according to the previously described taxonomies. Due to the number of these items, the analysis time per application varied from half an hour to three hours. The results of this analysis were recorded simultaneously to another separate Excel spreadsheet. In addition to the analysis, all the applications were left running in the background for at least two weeks to be able to detect all push notices and reminders. This was found out to be a good strategy, as some applications revealed their content better during this time.

BCT Taxonomy	1	2	3	4	5	6	7	8	9	10
1 Goals and planning										
1.1 Goal setting (behavior)	0	0	1	0	0	1	0	0	0	0
1.2 Problem solving	0	0	0	0	0	0	0	0	0	0
1.3 Goal setting (outcome)	0	0	1	0	0	1	1	0	1	0
1.4 Action planning	0	0	0	0	0	1	0	0	0	0
1.5 Review behavior goal(s)	0	0	0	0	0	0	0	0	0	0
1.6 Discrepancy btw current behavior and goal	0	0	0	0	0	0	0	0	0	0
1.7 Review outcome goal(s)	0	0	0	0	0	0	1	0	0	0
1.8 Behavioral contract	0	0	0	0	0	0	0	0	0	0
1.9 Commitment	0	0	0	0	0	0	0	0	0	0

Figure 10: An example table from the Excel spreadsheet (first ten applications showing)

The coding of behavior change techniques was conducted by very strict criteria presented by Michie and her colleagues (2013). The identification of these techniques was not always easy, considering that they were originally created for health intervention planning and evaluation in real life. Therefore, there exists no detailed advice how to identify them from mobile applications. The directions of Michie and her colleagues were therefore interpreted quite “by the book” and both the original article and the BCT taxonomy mobile application were repeatedly consulted. As an example of the strict interpretation, the mere existence of the possibility to change behavior outcome goals (which can be done anytime in all the applications with the possibility to set goals), was not coded as “Review outcome goal(s)”. In this thesis, it would be coded as such only if the goal reviewing prompt would come from the application. Another example comes from gamification, where email possibility was not coded as “Relationships”, because in the explanation of the taxonomy it included the concepts like “teaming” and “cohorts” and email possibility does not constitute those.

Final data analysis was conducted partly by Excel and partly by IBM SPSS Statistics 23. Data gathered to separate Excel sheets were exported to a single SPSS data sheet. As the scope of

this thesis was to describe what behavior change techniques and gamification features are used in mobile applications for chronic disease self-management, only simple descriptive statistics were calculated. Most of the variables were nominal, so it also limited the calculation possibilities, as well as the small research group.

6.4 Results

A total of 20 mobile applications suitable for tracking multiple chronic issues were found and analyzed. Table 4 demonstrates the amount of all investigated features from all the applications. The mean amount of behavior change techniques found in these applications was 7,2. As the table reveals, the variance was however very big, from 1 to 22 behavior change techniques out of possible 93. The same can be seen with gamification features. The complete list of all separate applications and the number and percentage of their features can be found in appendix 3.

	App functionalities (n=10)	Measurements (n=22)	Behavior change techniques (n=93)	Gamification features (n=42)
App n	20	20	20	20
Mean	4,15	10,60	7,20	5,85
Median	4,00	9,50	5,00	5,50
Mode	6	9	2	2
Std. Deviation	2,834	4,147	6,338	4,209
Minimum	0	2	1	1
Maximum	10	18	22	18

Table 4: General statistics of mobile applications

Considering especially the total amount of behavior change techniques and gamification features, this table shows that these features were not well utilized in the mobile applications. In the following subchapters, the general characteristics and measurements will be described together with the behavior change techniques and gamification elements found.

6.4.1 General functionalities and measurements

Most of the analyzed applications were categorized as health and fitness applications in iTunes. There was no mention of categorization as a medical device in any application, not even those in the medical category. Fourteen applications were only in English and six could be used in multiple languages. The most popular other languages were German, French, Italian and Spanish. One of the applications was also in Finnish, which could be well understood but not covered by the entire application. Eight of the applications were from the USA, two

were from the UK and one application was from Germany, France, Canada, Australia, Philippines, Poland and India each. There was no mention of manufacturer nationality in three applications. Only two of the applications were made for a certain healthcare organization; all the others were made by IT companies or private persons (2).

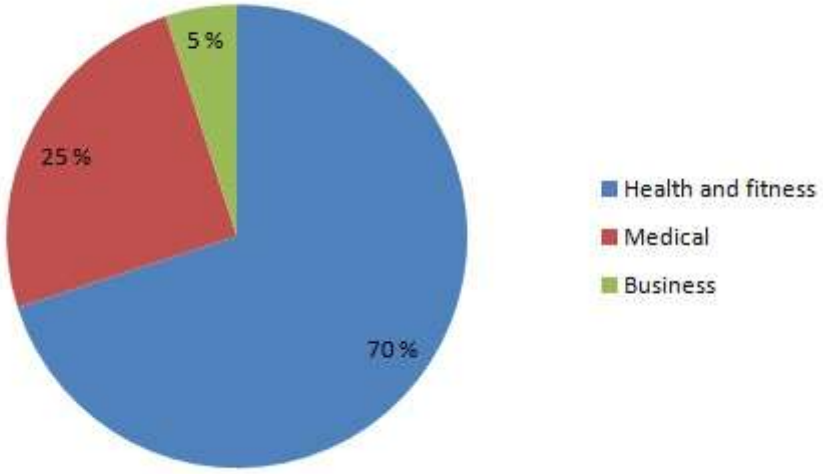


Figure 11: Categories of mobile applications

In total 40 % of the applications required signing in. This could be accomplished through the application in all the cases. Strong identification was not required in any of the applications, only normal username and password were required. Most of the applications, 80 %, were free. The four remaining applications cost 0.99 e, 1.99 e, 2.99 e and 3.99 e. In the analysis, it was easy to see that there was no connection between the cost and the amount of behavior change techniques or gamification features of the applications.

Certain general functionalities were recognized in the applications. The most popular functionalities were graphs, email and the possibility to lock the applications with a pass code. Reminders were enabled in 40 % of the applications and social media connectivity, mainly Facebook and to some extent Twitter, were possible in 35 % of the applications. Same amount reported the possibility to connect various devices, like activity trackers, data into the applications. Only one-third or less reported the possibility to create reports, take photos or be used by several users. A quarter of the applications promoted the possibility to connect healthcare professionals to the data provided by the user through the application; however email possibility was present in more. Directions may vary in different countries, but at least in Finland it is not allowed to send or receive emails to/from patients unless it is encrypted. None of these applications reported the possibility for encrypted email.

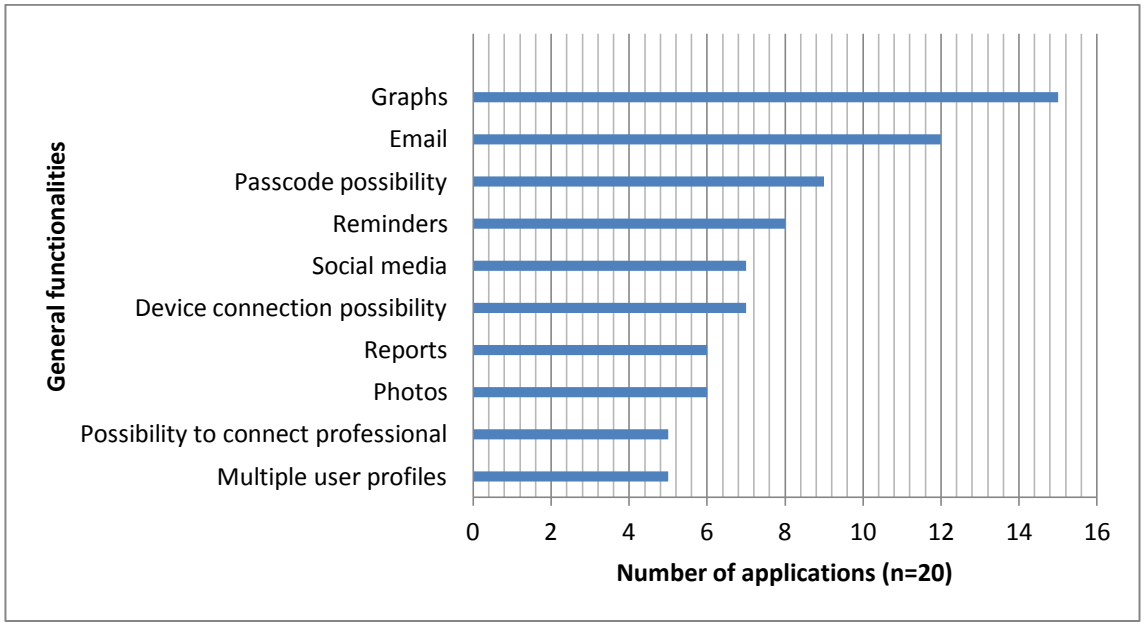


Figure 12: General functionalities in the applications

The measurement reporting possibilities in the applications were quite numerous. Almost all enabled the possibility to report weight and blood pressure measurements, both systolic and diastolic. Pulse, blood glucose, exercise and height were possible to report in around 60 % of the applications. Approximately 50 % offered the chance to write down the medications in use and report temperature, diet and BMI either by self-report or calculated by the application. Writing down symptoms or reporting sleep and mood was possible in 40 % of the applications.

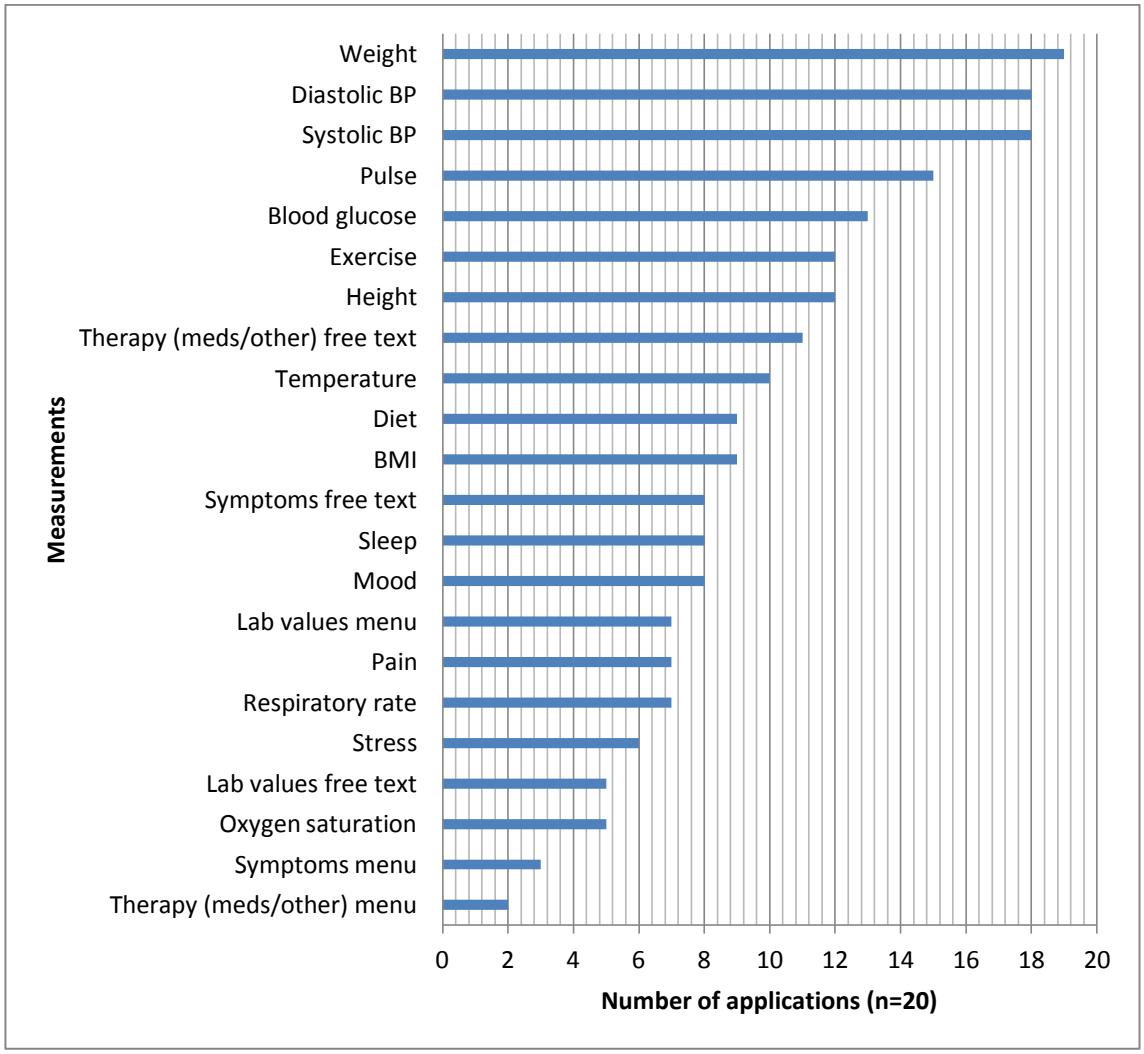


Figure 13: Measurements in the applications

Less than 40 % of the applications enabled reporting pain, stress and respiratory rate. Some laboratory values, usually cholesterol related, were possible to either choose from a menu or write down separately. Symptom and therapy related issues were more often possible to write down than choose from a menu, which is understandable considering the huge amount of possible medications and symptoms. Some note making possibility was present in most of the applications, and it is also worth mentioning that in many of the applications it was possible to add new measurement items for one's liking.

6.4.2 Behavior change techniques

As described at the beginning of this chapter, the mobile applications contained in general 7,2 behavior change techniques, which is 7,8 % of all the possible behavior change techniques. However, most applications contained less. This means that 55 % of all the apps have

five or less behavior change techniques in them. Even the application with most behavior change techniques takes advantage of only 24 % of the possible amount of the techniques.

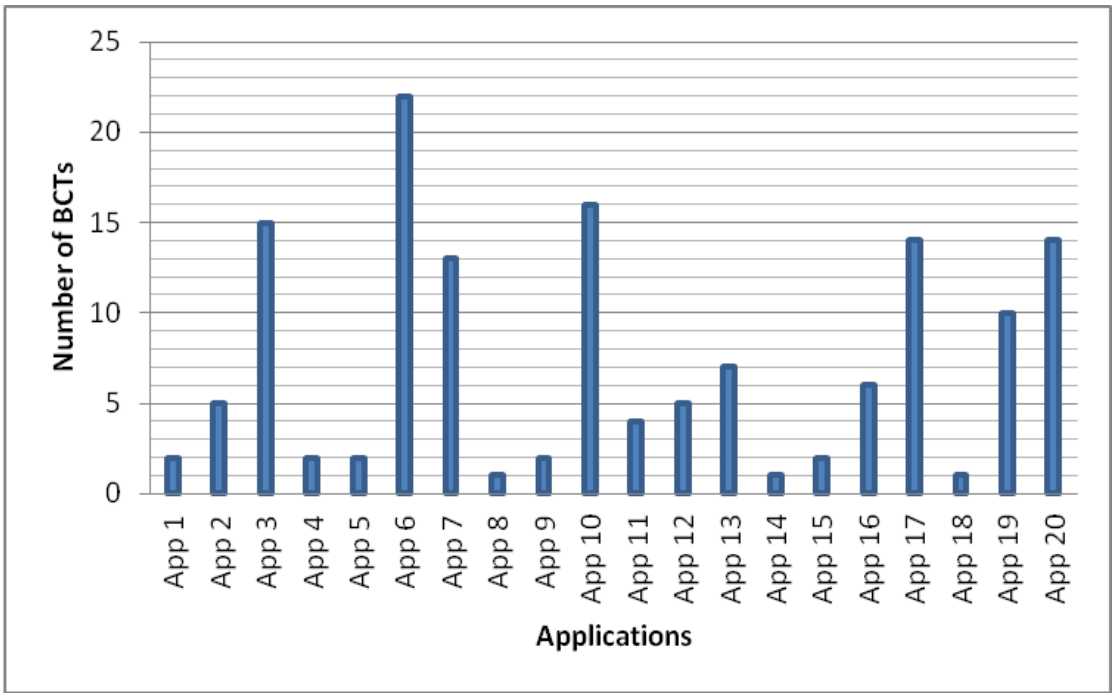


Figure 14: Number of behavior change techniques (n=93) in each mobile application

One purpose of this thesis was to investigate what behavior change techniques are being used in the mobile applications suitable for multiple chronic disease self-management. In addition to finding out the small usage percent of the behavior change techniques, the analysis revealed which behavior change techniques were used most. They are presented in the following figure 15, which presents only those behavior change techniques used at least once. The behavior change techniques not used at all are left out of the figure. Only 44 % of the possible 93 behavior change techniques were identified in the mobile applications. This shows that there are many known techniques that were not utilized. Naturally 100 % usage of these techniques can never be achieved in one mobile application but there is clearly room for improvement.

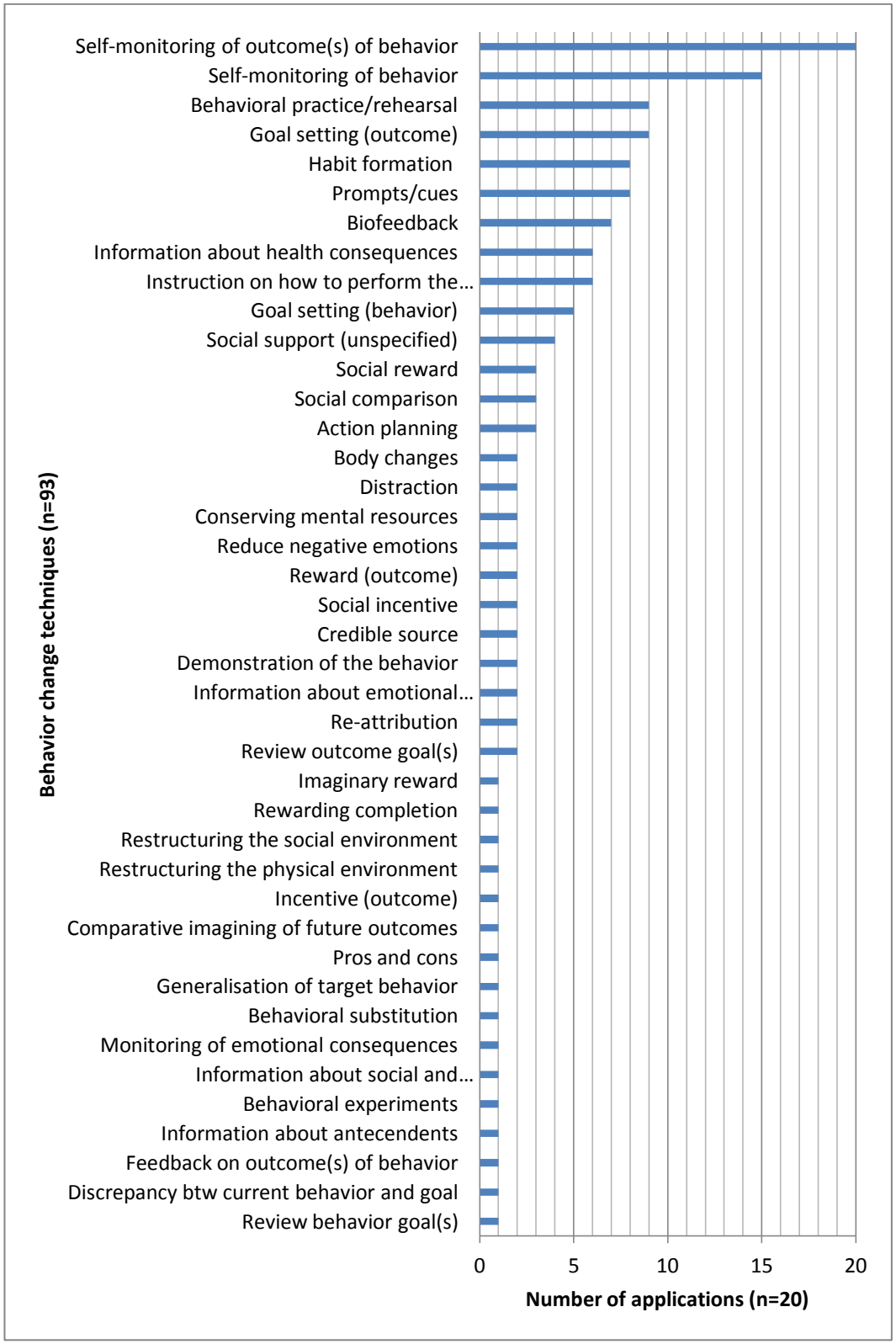


Figure 15: At least once identified behavior change techniques in mobile applications

As one of the inclusion criterions was the ability to report measurement and/or monitor health, it is not a surprise that the behavior change technique most often used (100 %) was "self-monitoring of outcome(s) of the behavior". Most often these outcomes were weight,

blood pressure and pulse. Second most prevalent behavior change technique (75 %) was “self-monitoring of behavior” which consisted mostly of exercise and diet related monitoring.

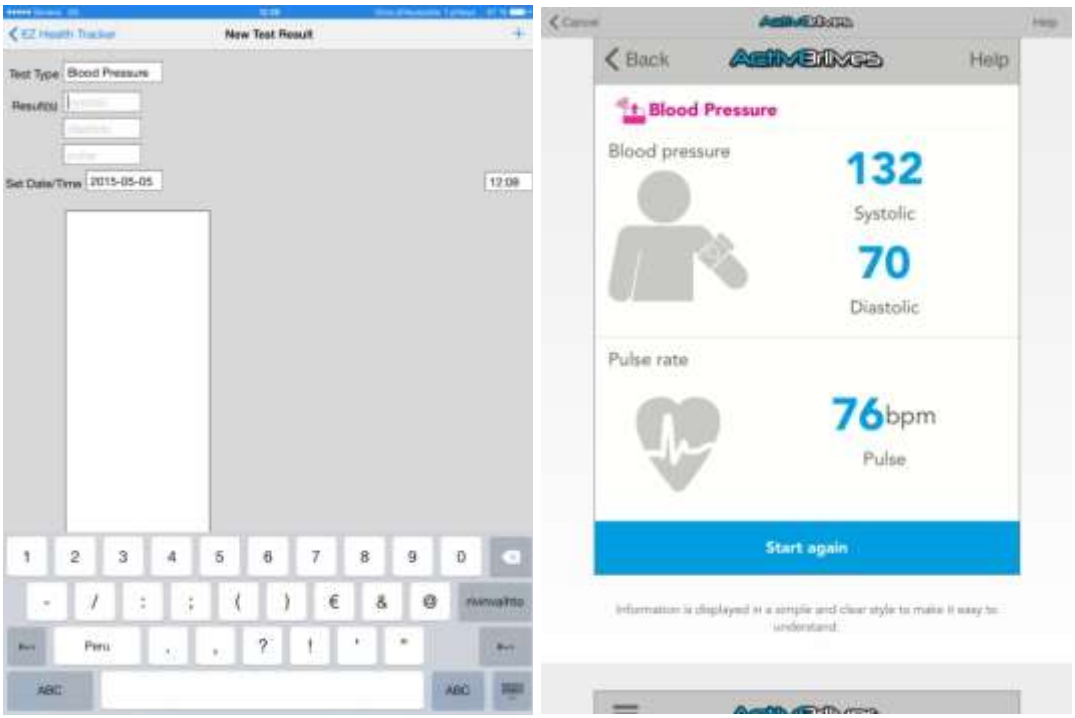


Figure 16: Examples of reporting and reviewing self-monitoring data in a simple way

It is clear that mobile applications can be well used to remind people of various tasks. In general, 40 % or more provided the possibility for reminders, which can act as prompts to re-hearsing behavior. As behavior repeatedly happens due to prompting, it has more chances to become a habit. “Goal setting of behavior outcomes” (45%) was more prevalent than “goal setting for behavior” (25%). In this thesis, the “biofeedback” was coded if there was a possibility to connect some external fitness or another device to the application, which could then automatically send biofeedback to the application. This possibility was detected in 35 % of the applications. This feature was not however tested, so it is not certain if they worked properly.

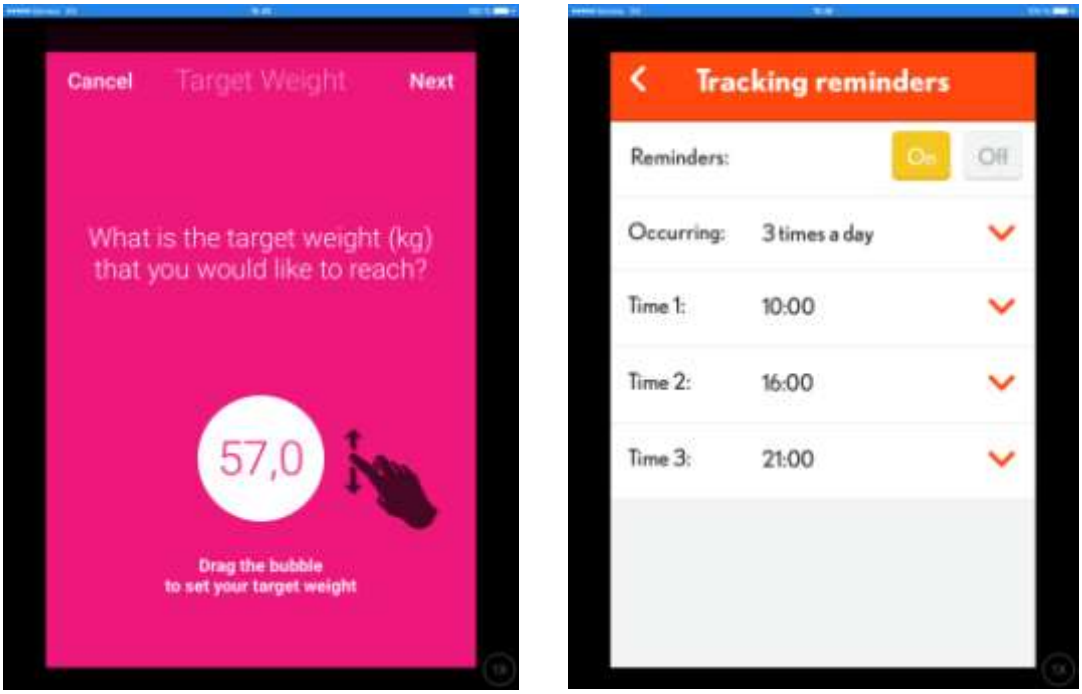


Figure 17: Examples of goal setting of behavior outcome and creating prompts

Educating people and giving instructions were present in 30 % of the applications. Information about health consequences was usually presented in a separate part of the application, as well as instructions too. In the applications that presented this kind of information, it was also often provided as separate emails or push notifications to the mobile device.

Figure 18: Example of educating and instructions

Social aspects like “social support (unspecified)”, “social reward” and “social comparison” were present only in 20 % or less of the applications. The mere possibility to contact someone by email was not coded as social support in this thesis, as the taxonomy states that for example “mention of follow up” not enough. The possibility to email was placed in that category. Social support was coded if for example a clear invitation was provided to participate as in figure 19.

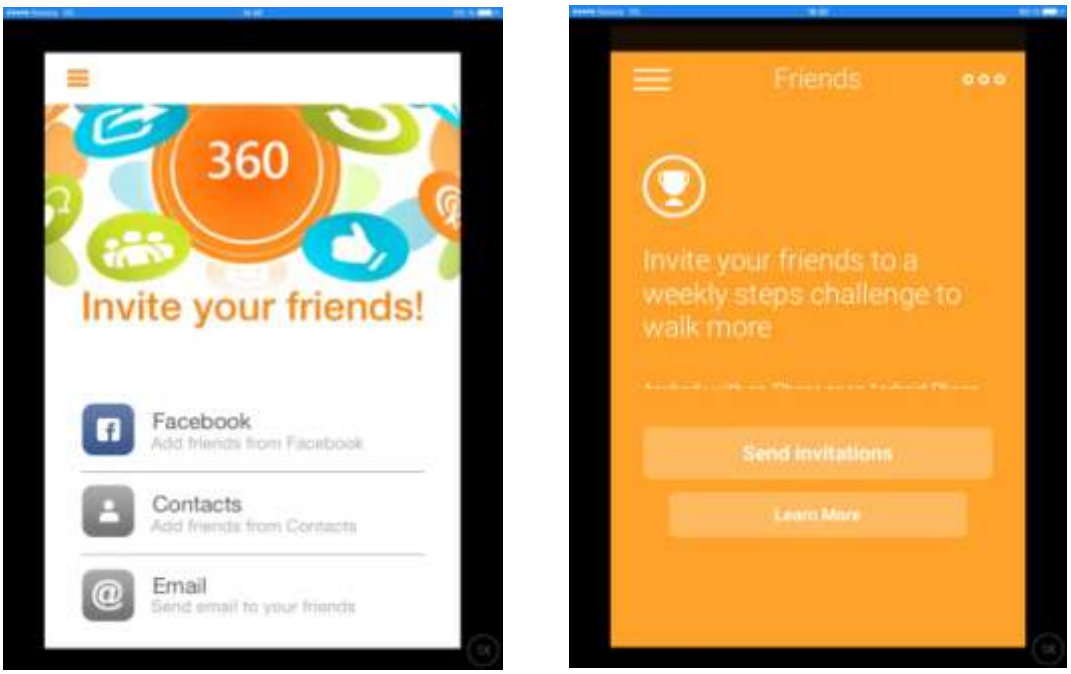


Figure 19: Examples of invitations to participate

Surprisingly few other behavior change techniques were present in the analyzed mobile applications. Apart from “action planning”, which was present in three applications all the other behavior change techniques were present in two or fewer applications. It was not the scope of this thesis to rank these applications. However, to provide tools for healthcare professionals and consumers alike, three applications with most behavior change techniques were Health Mate – Steps tracker & life coach by Withings, My Crittenton Health Tracker and Activ8rlives 3.0 Health Monitoring and Food Diary App. It should be remembered that this ranking is only for behavior change techniques and does not take into account any other features, like usability or design.

6.4.3 Gamification features

The analysis of the mobile applications revealed big variability of gamification features used. On average, the applications had 13,9 % of the possible features. However, the range varied from 2,4 % to 42,8 %, as some of the applications had only one feature and one had 18. The

analysis revealed that most of the applications were not designed gamification in mind, while on the other hand couple of them had very clear “gamified” feel, as we can see in figure 20.

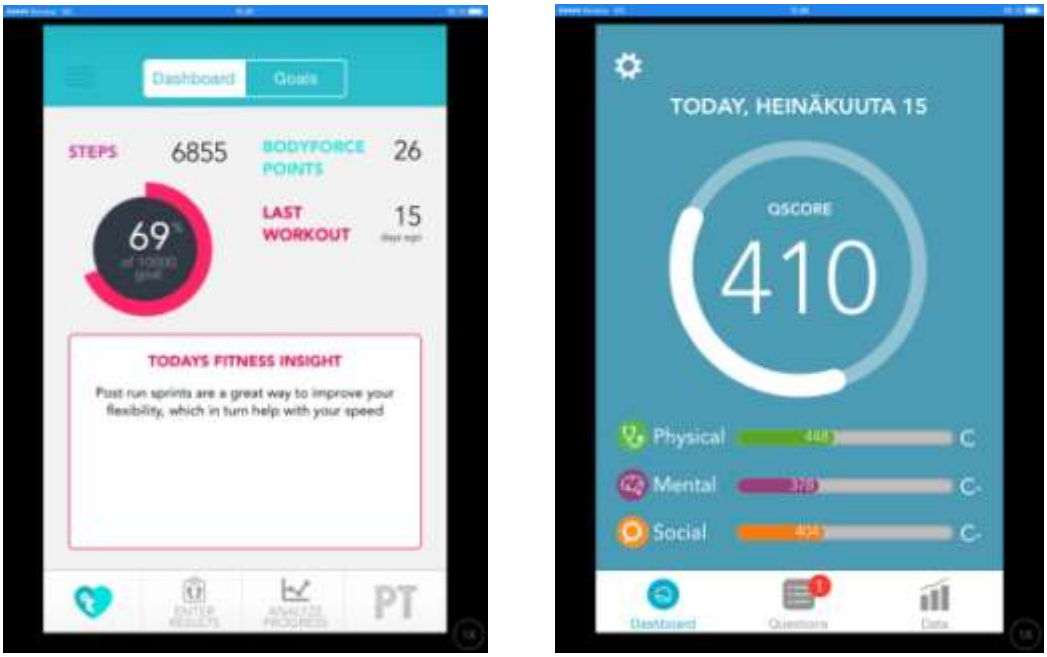


Figure 20: Examples of a ”gamified feel” or design

As can be seen in figure 21, 80 % of the applications had seven or fewer gamification features. In addition to that, nearly half of them had less than five. The gamification taxonomy used in this thesis consists of 42 different gamification features, so it is clear they were not utilized as well as they could have been utilized in most of these applications.

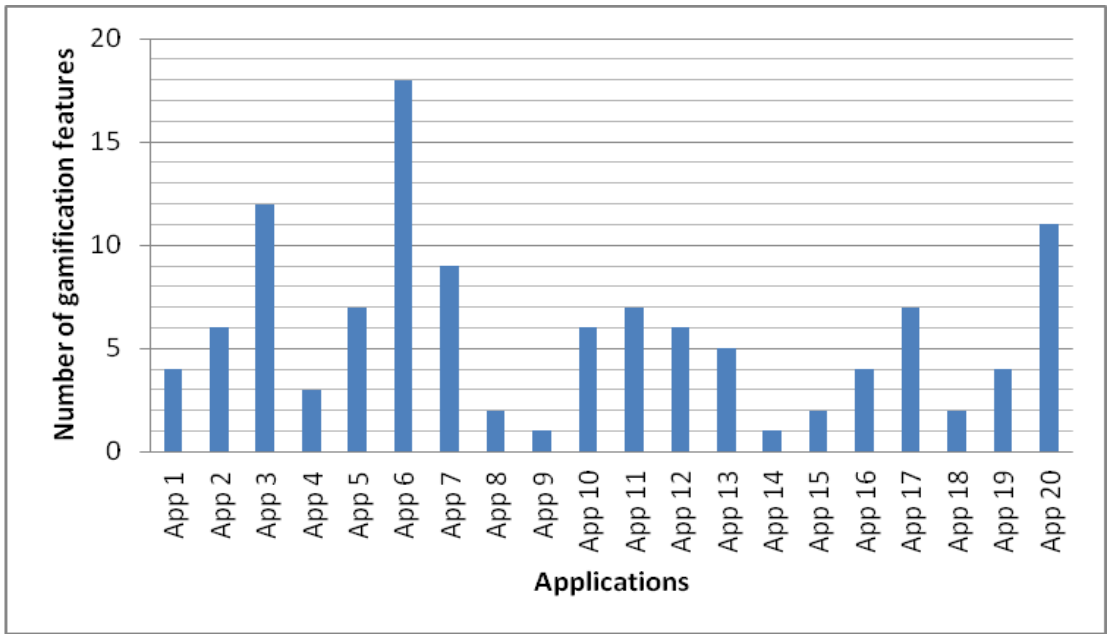


Figure 21: Number of gamification features (n=42) in applications

Context is the specific setting of the gamification scene that is chosen, not designed. As these applications were all in a specific context, a mobile application, it was 100 % present. Some other contexts could be workplaces, websites or other similar settings. The gamification taxonomy used in this thesis views records of achievement as part of feedback and status information. It can include levels or grades, points, badges, progress towards objective or historical information like performance gauge. Considering that many applications used self-monitoring and graphs to follow, the "records of achievement" was the second most prevalent gamification feature by 80 % in these applications. In figure 22 are displayed all the features present at least in one application, those which were not identified at all are left out.

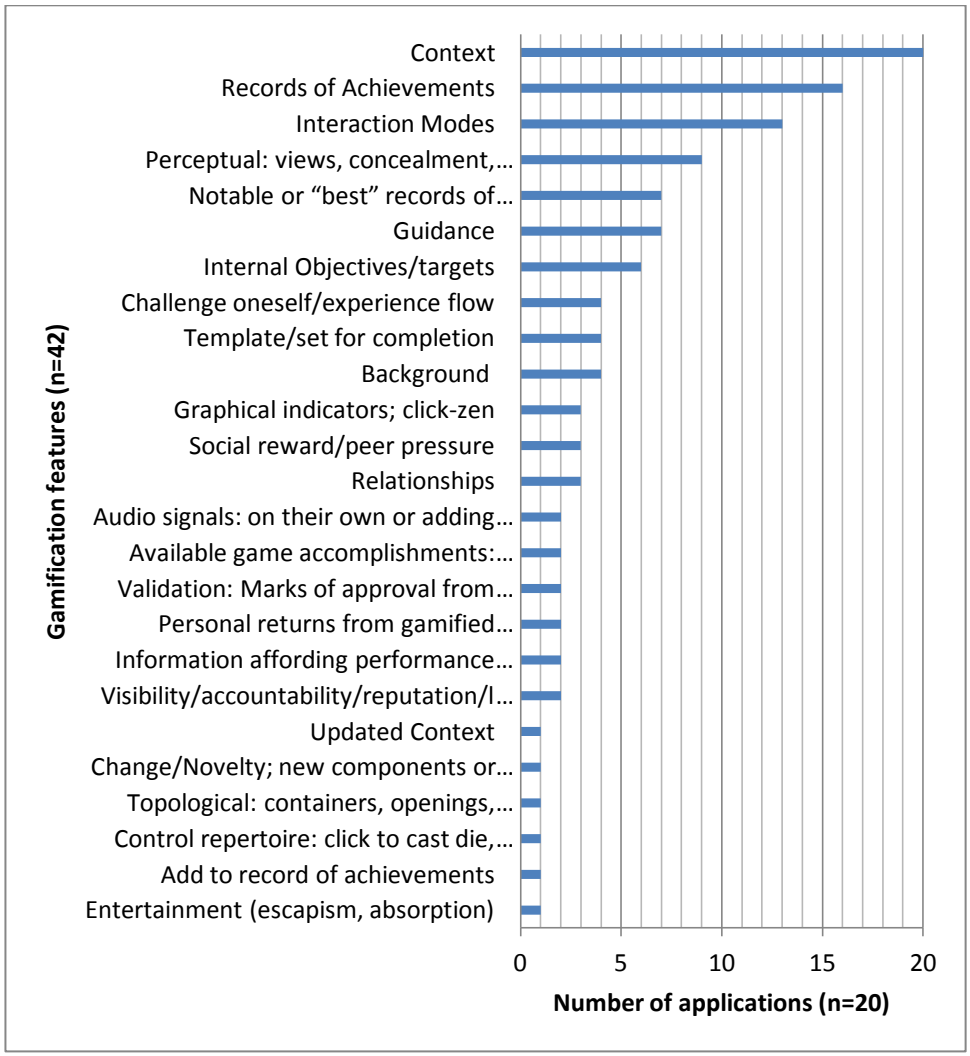


Figure 22: At least once identified gamification features in mobile applications

"Interaction modes" were identified in 65 % of the applications. In these applications they were mainly interaction channels like email, but the taxonomy also recognizes competition, collaboration, gift giving and trading. On the other hand "social reward" and "relationships", which are presented as more of a bonding or teaming in the taxonomy, appeared only in 15 %

of the applications each. “Perceptuality” was present in 45 % of the applications, mostly in the form of audio prompts or visual push notifications. 35 % of the applications had some “best records of achievements”.

Figure 23: Example of best record achievement

“Guidance” was present in 35 % of the applications, mainly as instructions to do something in a certain way. “Internal objectives” in these applications were mostly task executions like filling in the blanks, and they were present in 30 % of the applications. Some of the other gamified internal objectives could be correct answers, missions or choices. “Challenging oneself” was present only in 20 % of the applications, as well as “background” and “template/set of completion.” A set of completion could be an announcement of a profile not yet completely fulfilled or answering all questions. An example of a set of completion can be seen in figure 24:

Figure 24: Example of set of completion

All the other gamification features were present in 15 % of the applications or less. In total, out of the possible 42 gamification features 40 % of them were not identified at all in the applications. Again, the purpose of this thesis was not to rank these applications but for those interested in mobile applications for chronic disease management with most gamification features, the top three applications were Health Mate – Steps tracker & life coach by Withings, Activ8rlives 3.0 Health Monitoring and Food Diary App and BodyWise - Health & Fitness Tracker. It should, however, be remembered that this ranking is only for gamification features and no other features like usability or design.

7 Constructing a new framework for behavior change techniques

In today's hectic world, we are constantly bombarded with external stimuli and impulses. All this affects our motivation, actions and priorities. West recognizes this in his model for motivation discussed previously. Decisions and actions people make are the results of this constant dialog. In healthcare we like to think that people are rational, and as long as they are told what is good for them and are given information, they will act accordingly. It is true that information matters, but it is unfortunately often buried under the requirements of everyday life.

People with chronic diseases, depending on the disease, have healthcare appointments usually from one to five per year. Multiple morbidities often result in even more appointments as different diseases are usually treated in different healthcare facilities. However, even if a patient has ten appointments per year, each lasting an hour, she is having direct healthcare and guidance for only 0,1 % of that year. The cost to the society will be around 1400 euros, not including any medications, special treatments or absence from possible work. All the other 99,9 % of the time she under the influence of family, colleagues, acquaintances, media and all the conflicting information from them.

One way healthcare can reach patients in their everyday life better is through the use of mobile devices, which usually are almost always with them. As discussed previously, there are already a huge amount of mobile applications for fitness, diet, individual diseases and even for multiple chronic disease management. What we know from previous studies and the empirical part of this thesis is that they do not address changing behavior very well. There are also some known biases described in the behavioral economics literature, which affect the behavior and decision making of people and are seldom taken into account while developing any healthcare services or interventions. These will be discussed more in detail in the next paragraph. After that, the creation of a framework for behavior change technique intervention process is described. This will be done using methods of service design as well as utilizing existing theory, experience and previous research.

Behavior change techniques taxonomy by Michie and her colleagues (2013) is a big asset to anyone planning or evaluating services with a behavioral aspect. Even though the techniques are grouped under themes and explanations are provided for each and every one of them, the applicability to real situations remains somewhat elusive from the healthcare point of view. The main reason for constructing this framework is to try to provide a tangible step-by-step example, which is easier to grasp; a bit more like a service. Focusing on a chronological display of the techniques will hopefully constitute a practical service tool for the use of larger audience from various disciplines.

7.1 The aspect of behavioral economics

Behavior and the choices resulting from it have substantial effects on health, and eventually also on the socio-economic state of the society in a larger scale. Not only does behavior affect the economy, but the economy also affects behavior. There is a need for new understanding of human decision making in the context of behavior change, and the National Institute of Health has proposed (2009) including behavioral economics approach as one of the possible new aspects in designing health interventions.

Behavioral economics is an approach originating from the work of psychologists Daniel Kahneman and Amos Tversky, as well as the work of economists like Richard Thaler. This field explores the economic aspects of human decision making and explains why providing information to people does not necessarily lead to rational changes. In 1979, Kahneman and Tversky created the quite complex prospect theory, which states that people, finding themselves obliged to make decisions under uncertainty, go through two different stages while making the decision. First, they edit complicated possibilities to simpler ones by evaluating possible losses and gains based on the situational circumstances they are at. Secondly, they make decisions between these edited prospects based on the value of different options and the weight they bear. People usually prefer certainty, want to avoid losses and tend to underestimate events that are unlikely to happen. (Kahneman & Tversky 1979.) Previous sentences present the very oversimplified description of the whole theory. Prior to the prospect theory, Kahneman and Tversky published a paper (1974) which presented biases, certain predispositions or skewed thinking and heuristics, certain shortcuts in people's thinking, which can affect people's judgement. The whole idea is that even though people think they make rational decisions, they seldom do because these heuristics, biases and situational effects affect thinking.

There are some others aspects in behavioral economics too. The dual-systems theory describes two different thinking systems: the fast and intuitive one and the slower, analytical one. The first system, the fast system, is the origin of different mental shortcuts like availability, which proposes that if something is easily at hand the possibility of it is

considered higher, and affect, which explains why the sole good of bad "feeling" about something affects thinking. Humans also have an aversion to change, which falls under the status quo bias. Temporal dimensions are presented in time discounting, which proposes that present events matter more than events in the future. People are much more prone to accept 100 euros now than 110 euros after one month. Social norms and fairness are also important aspects of decision-making; people have the tendency to return a favor with favor. However, the same social norms stop people for paying money to a friend for example for preparing a meal, even though that is what is done in professional situations, like restaurants. (Samson 2014, 4-9.) Using behavioral economics principles at their simplest can be taking into account:

1. Small changes can have large effects
2. Psychology is really important
3. People can't always explain why they do what they do, or what they want
4. Preference is relative and social and contextual, not absolute
5. Trust is never a given; commitment really matters
6. People satisfice

Table 5: Simple behavioral economics principles by Rory Sutherland (Samson 2014, XVII)

Understanding the possible biases and heuristics is essential when planning health interventions. Unfortunately, this area remains not well studied. In a research about genetic testing, creating a default set of results and giving an additional option to receive more information if wanted, is assumed to lead to patients not seeking for more information or second opinions (Blumenthal-Barby, McGuire, Green & Ubel 2015, 2). These aspects and many more from the Behavioral Economics Guide 2014 (Samson 2014) were used in the process of creating the final framework.

7.2 Service design thinking approach

Lukka (2006, 116) states that constructive research approach does not dictate certain methods for the stage of creating the new construct, the new solution or model for the problem. Although the development of this framework in this thesis is not a service in the traditional sense, the idea of service design thinking guided the creation of it. Stickdorn and Schneider (2011, 23) cite the Copenhagen Institute of Interaction Design while stating that "service design as a practice generally results in the design of systems and processes aimed at providing a holistic service to the user". This was the main focus in the development of this framework.

Design thinking can be seen as a creative process focusing on the building of new solutions by synthesis and ideation. In addition to synthesis, some other methods used are visual communication and prototyping. (Aminoff, Hänninen, Kämäräinen & Loiske 2010, 5-6.) All these methods are used in this part of the thesis. The principles of service design (Stickdorn & Schneider 2011, 26) were approached somewhat liberally in this development process. The user-centeredness was the guiding principle. The purpose was to create a framework, which could ease the comprehension of the behavior techniques and be hopefully well understood by all, no matter whether a healthcare professional or a mobile application designer. The co-creativeness appeared in the fact that these techniques are the result of many researchers approaching different sides of the same phenomenon, and the creation continued in this construction process. Sequencing and evidencing were pursued by bringing the timeline and the journey visible. Finally, the whole framework was built with a holistic scenery in mind, trying to take as many sides as possible into consideration.

It was difficult to create a traditional service blueprint or patient journey map out of behavior change techniques. Therefore, this framework took more resemblance to process mapping or an intervention lifecycle map derived from a customer lifecycle map. Narrative of the complete process was created for easier understanding of the behavior change techniques. However, the most important aspect was a visualization of the whole scenery, as it made the behavior change techniques more alive.

7.3 Developing the framework

The process started naturally with sticky notes. All 93 behavior change techniques (Michie et al. 2013) were written one by one to 93 different orange notes. A brief explanation of the technique was also written on the note. Then 40 green sticky notes were written with behavioral economics heuristics and biases chosen from the Behavioral Economics Guide (Samson 2014). Similarly, a brief explanation was inserted to those notes too for grouping pairing later on. Originally also the pink gamification features stickies were included in the creation process, but they were soon discarded, because of the huge amount of notes and the partial similarity with the techniques. The guiding idea was to begin with the behavior change techniques and combine the notes with similar meanings or approximate meanings to groups. First this was done with the techniques, then with the gamification features and finally the behavioral economics notes were inserted over the techniques that should either embrace or find ways to deal with certain heuristic or bias. All the behavioral economics notes were numbered from one to 40, and at the grouping all possible behavior change techniques showing some connection were also coded similarly, as can be seen in figure 25.

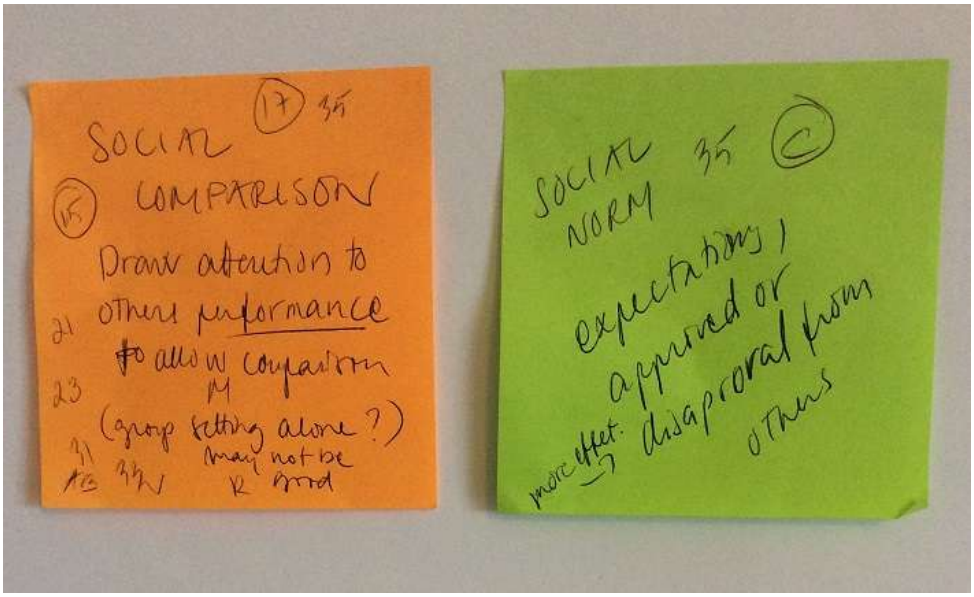


Figure 25: A close-up of the numbered BCT and BE notes with explanations

A notable aspect is, that the behavior change techniques once grouped, immediately formed a timeline with a very strong cluster of behavior change techniques at the upper left corner creating a natural starting point, following with three different paths. Those paths are drawn over the notes in figure 26 for better visibility. There is also another picture with all the sticky notes attached at that point.

Figure 26: Behavior change techniques with drawn path and all notes attached

At this point it became clear, that there were too many notes and too crowded space, so gamification features were discarded at this point. After that, first the behavior change tech-

niques were inserted into a new, bigger platform where they formed similar timeline as before but in more easily approachable format. The movement of the process was better seen this way, and again arrows were drawn over the figure 27 to illustrate the paths better. The different parts of the journey were given descriptive names on top of the timeline. Finally, the behavioral economics aspects were grouped under the behavior change techniques by the order of previously combined numbers. As there were many behavior change techniques that were compatible with a single behavioral economics aspect, the behavioral economics notes were lined to the place where they had the most compatible behavior change technique over them.

Figure 27: The concepted timeline of the journey

The bigger picture was forming now. Parts of the formed timeline were identified as “need for change”, “intervention”, “affirmation”, “patient everyday life”, “preparing for relapse”, “review – success or relapse”, followed by “everyday life continues – continue like before or modify intervention” and “other tools”.

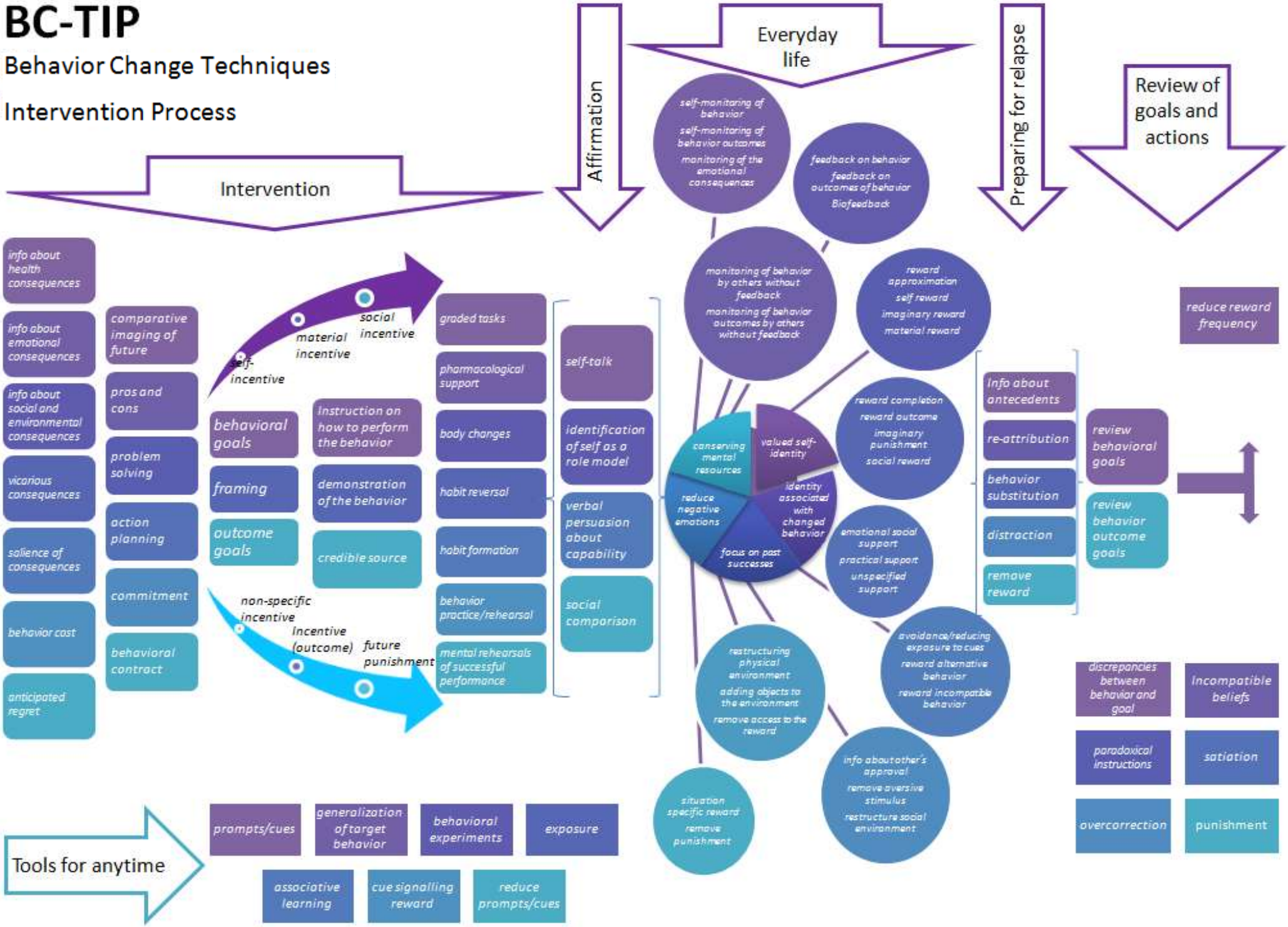
7.4 Outcome: the BC-TIP framework

The main reason for developing this framework was the need to create a clearer, visual tool from the theory derived behavior change techniques, so that they can better be used while developing effective mobile applications for health behavior change or any kinds of interventions, whether for a single person or groups. Therefore, it was given a name BC-TIP, which reminds of its usability as a helpful hint for behavior change and is derived straight from “Behavior Change Techniques Intervention Process Framework”. The visual presentation of the BC-TIP is presented first, and the main constituents follow. All the behavior change techniques are presented in italics in the narrative.

BC-TIP

Behavior Change Techniques

Intervention Process



7.4.1 Intervention phase

All begins with the need for change, initiated either by a client herself or healthcare professional in some situation. Intervention is the first step after that. It comprises of a process of building motivation by providing *information about health consequences* if nothing changes, providing *information about emotional consequences* and possible *social and environmental consequences*. Then the aspect of *vicarious consequences* is brought up, guiding people to think back consequences for other people when they succeeded or failed some health related act. *Salience of consequences* can be emphasized here by presenting, for example, graphic visual elements. The *behavior cost* and future *anticipated regret* can also be discussed at this point.

Next the *comparative imaging of future* and *pros and cons* can be brought up. People may need to be reminded even more of what will happen for example if bad habits continue. Discussing together all sides and aspects of potential behavior change can create new positive ideas to support the change. It is of utmost importance at this point to *solve problems* together with the client. The change will not be possible if there are some obvious problems like lack of time, difficult family situation or other problems. At this point, it is essential to find solutions to those problems as well as possible to create the potential for change. Also, clear *action planning* with concrete ideas about behavior change with frequency, duration or intensity can be discussed. If the plan is to lose weight by exercising, the what, when and how often is good to plan ahead. Concrete *commitment* is needed as well as a real *behavioral contract*, preferably in writing and witnessed.

There is nothing more important than clear goals. Setting both *behavioral goals* (like walk two kilometers every other day, rain or shine) and *outcome goals* (will lose weight five kilograms in next three months) are helpful in creating change. At this point, some *framing* might be useful in changing perspective, so it might be good to remind for example that starting exercise is not about becoming an athlete but being able to see your granddaughters wedding some day. Also other incentives for the behavior are good to remember; choosing right ones from *self-incentives* (will do something nice for myself if I continue walks), *material incentives* (promise of a voucher or like if walks continue), *social incentive* (friends will cheer if continue walks), *non-specific incentives* (can use facility's pool if continues walks) or *incentivizing outcome* (new clothes are waiting if lose five kilograms). As opposed to incentives, some people might respond better to an idea of *future punishment* (will develop diabetes if no weight lost).

People also need examples. *Instruction to perform the behavior* and *demonstration of the behavior* may work best if they come from a *credible source* like a professional or a credible

public figure; in person, on film, on brochure or maybe through a mobile application. Some steps to consider before clients go home can be giving *graded tasks* from easy to harder, using *pharmacological support* when in place and promoting measures to turning attention to *body changes* by before and after pictures, strength training or simply providing hearing aid if needed. Providing tips *for habit reversal*, like taking stairs instead of a lift may lead the way for new *habit formation* of taking the stairs every day. This can be underlined by encouraging *behavior practice/rehearsal* in other behaviors too, like doing some hand exercises while walking, even though it is usually done only at the gym. Finally, providing clients with *mental rehearsals of successful performance* may prove beneficial when they are experiencing doubt.

There are some lessons learned from behavioral economics that need to be noticed while considering the intervention phase. People prefer things like they are, in status quo. That may have them doing seemingly irrational things in avoidance of change. That is why it is important to address possible problems and obstacles together and find solutions so that they cannot act as an excuse. It may well be useful not leave the decision about whether to change to the client alone, because of this aspect. Decoy effect can be used by providing her always at least one harder choice than where the commitment is needed. People are also very often overly optimistic and confidence about their abilities and time. This may lead to too big plans and changes at once, resulting in a choice overload that may freeze the person completely. Therefore, it is important to plan just a few goals at a time and really make a commit to them, preferably publicly as it increases the chance of complying. People may also underestimate the chance to get diabetes and even joke, in half-belief, that they will probably die in a plane crash anyway, so why bother doing anything for health. We are not rational, and the more some things are in the news, the more we remember those things as a real threat. This can be however also be used as an advantage by reminding people of public figures who had “this” and then did “that” and saved their health by doing so. Habits can be backed up by concrete things. A note on a bathroom mirror reminding of flossing, or a reminder from a mobile application at a certain time of day to pursue something agreed.

7.4.2 Affirmation

One of the most important aspects of health behavior change is an affirmation. It may come from healthcare professionals, friends, family or from mobile applications, but it needs to come. It also can come from within, so prompting positive *self-talk* is a good starting point. It may also be good to remind people that they are role models to someone. Therefore *identification of self as a role model* should be encouraged. Changing behavior is not easy, so *verbal persuasion about capability* is essential. Finally, one of the strongest motivators can be *social comparison*. This can be guiding people’s attention to someone else succeeding or guiding people to social support groups.

When referring to behavior economics, it is clear that people have decision fatigue. Even though intentions are good, faced with everyday obstacles these decisions may fade. When affirmation comes from somewhere, it gives strength. Social norms cannot be emphasized enough, both peer pressure and comparison may work wonders. People also tend to overvalue what they own, so this trait can be turned to positive by really emphasizing self as a role model. If this position is really "owned", it can be one of the biggest motivators. Affirmations work on one of the biggest demotivators, the knowledge that similar effort in the past has failed. To overcome this notion, affirmation is needed.

7.4.3 Everyday life

Most of the time people live their normal lives in their own surroundings. There are many things to consider and plan, to make the initiated behavior change to last. Considering chronic disease, usually some *self-monitoring of behavior* (tracking exercise) or *self-monitoring of behavior outcomes* (blood pressure) is needed. Something often neglected is *self-monitoring of the emotional consequences*. It is easy to forget the feeling of joy and pride after the first successful exercise maybe in years, but for example writing it down somewhere creates a concrete event, which can be consulted later when in doubt. It may give a boost to efforts to know that someone else is following these measurements. Therefore, *monitoring of behavior by others without feedback* and *monitoring of behavior outcomes by others without feedback* alone can have an effect. The bigger effect will probably follow, if *feedback on behavior* and *feedback on outcomes of behavior* follows. *Biofeedback* should be also remembered because this can easily be accomplished using well planned digital equipment.

What happens inside the mind of people during everyday life is important. There is always a need to *reduce negative emotions*, by stress management or related aspects. Making things easier matters too, like providing a dieter ready-made shopping lists to help in *conserving mental resources* while leading normal busy life. The important thing is to *focus on past successes* as together with this *new identity associated with changed behavior* will lead to *valued self-identity*, which can be underlined even more with writing exercises about this new self.

People need rewards for the usually hard changes they have accomplished. Something often forgotten is *rewarding approximation*. The first steps made need celebration, as they will lead further. It is important to *self-reward* with something appreciated, like *non-specific reward* as going to cinema, as well as with some *imaginary reward* or concrete *material reward*, which is big enough. *Rewarding completion* as well as *rewarding the outcome* reached cannot be forgotten. For some people an *imaginary punishment,* like imagining the guilt or

physical discomfort after overeating or indulging, can act as a big motivator at this point. *Social reward* cannot be overestimated; family and friends should be a part of the team. Rewards are something fairly easy to arrange digitally too.

Social aspect plays a very important role. Not only the rewards but social support in general. It can be *emotional social support* like arranging company for hard situations, *practical support* like helping with medication or *non-specific support*, which can be for example ongoing reminders of the need for the change. Social support from peers, friends or family can also include *avoidance/reducing exposure to cues for* unwanted *behavior*, like not going together to a bar if there is a need for reducing alcohol intake. They can also *reward alternative behavior* or *reward incompatible behavior*, like ordering juice instead of alcohol in certain situations. They can also speak their mind about unwanted behavior, which *gives information about other's approval*. However, sometimes speaking their mind or nagging about something can backfire, so *removing the aversive stimulus* can be in order. Sometimes even more radical changes are necessary and *restructuring social environment,* like a change of friends who are not supportive, may be needed.

It is possible to make other kinds of changes too. *Restructuring physical environment* may be needed. Why not bring in an exercise bike beside the sofa to bring choice for the time there is a favorite show on the TV. This is also *adding objects to the environment*. *Removing access to the reward* may also work, like locking the cupboard door where the sweets are and giving the key to a family member. Sometimes *situation specific reward*s, like rewarding eating only at mealtimes could work, and sometimes the biggest reward could be *removing punishment*, like someone else taking care of the house cleaning if desired change happens.

One of the biggest lessons drawn from behavior economics at this stage is that we have a dual system in the brain. There are the rational, considerate system and the fast, less controllable system. In everyday hurdles the fast system usually wins. Therefore, it is good to create good defaults, like making the unwanted choices harder to get and the wanted choices easier. Very concrete steps come in handy, like getting used to smaller portions by using smaller plates. Getting as much as possible of friends and family on board, and participating in support groups will help because people are prone to follow the lead of others close by. Helping other people with similar situations may also help because reciprocity is appreciated and investing time and effort makes it more valuable. People also appreciate present things more than things in the future. Therefore rewarding the small steps is important. This also helps people to deal with the fact that progress usually takes more time than estimated and to avoid the frustration, small rewards along the way will help.

7.4.4 Preparing for relapse

From the beginning, the subtle preparation for relapse is encouraged because it will usually follow at some point. There is the need to make sure that it is not the end of the world, and it should be treated only as a small bump in the road. *Information about antecedents* can be useful to point out, as sometimes negative thoughts or certain actions can predict the following relapse. Pointing alternative reasons for having a hard time with some aspect of change is *re-attribution*. At these situations, *behavior substitution* can be in place, like changing the routine for a while. *Distraction* may help, either as self-inflicted or turning to support group at an unusual time. If relapse happens, *removing reward* like people ignoring as long as unwanted behavior continues may help getting back on track.

Some insights from behavior economics imply that people get used to good things quite fast. The effort made may begin to feel irrelevant. The fact that a big effort was completed leads easily to allowing something desired, even though realizing it is not for good. Focusing on this stage by mini-intervention, and reminding of all the hard work already done, all the invested resources and all the possible losses following the possible relapse, may prevent the relapse as people usually fear loss more than hope for gains.

7.4.5 Review success or relapse

Reviewing behavioral goals and *reviewing behavior outcome goals* together with the other party with whom they were originally set, cannot be forgotten. It may well be one of the most important aspects of all. This review can also be built into some system digitally. If things have gone well, it is time to reward further and congratulate, and continue the support for life as usual or agree on new goals. At this stage, it may be appropriate to begin the *reducing of reward frequency*. Then the cycle begins again.

On the other hand, if there has been trouble in adhering to set goals or relapse, there are different possibilities how to proceed. *Discrepancies between behavior and goal* can be addressed. *Incompatible beliefs* can be addressed by drawing attention to discrepancies between current and past behavior and self-image. This is meant to create discomfort. Sometimes *paradoxical instructions* are needed. If chocolate seems to be impossible to get rid of, why not once eat it so overly much that a very big nausea follows. This is very similar to *satiation*. Another way is the contrary, *overcorrection*. When relapse happens, for example eating unhealthy fast food meal, advice to eat only fruits and vegetables the next day may help. At some situations, arranging *punishment* may be in order, depending on the situation naturally. Relapse may insinuate that the goals may not have been right ones originally, so agreeing on new goals is appropriate before continuation.

7.4.6 Other tools for anytime use

The order of the behavior change techniques in the last paragraphs is just a suggestion, an example. There are no interventions in real life which could utilize them all. Only some of them can be used, in various orders. Even a single technique in the right situation can prove to be very useful.

A couple of techniques are still left. They can be used as additional ones in any or all stages in the intervention, or as a single component by itself. *Prompts/cues* can be reminders from a mobile app, a phone call from a nurse or a sticky note on the refrigerator. *Generalization of target behavior* can sometimes make the behavior seem less demanding. Sometimes it can be good to make *behavioral experiments*, just by gathering information about it and then just trying. The result may be that it is not so hard after all. Sometimes it is just good to have *exposure* to a feared stimulus. *Associative learning* can help getting rid of unhealthy behaviors, like repeatedly eating something unhealthy but desired with something disliked. *Cue signaling reward* at any point may lead to positive outcome by creating anticipation, like incentives do. Moreover, finally, at some point *reducing prompts/cues* is done.

8 Conclusions and discussion

The original purpose of the empirical, content analysis part in this thesis was to describe how mobile applications for chronic disease self-management aim to change behavior and maintain it by analyzing the applications for known behavior change techniques and gamification features. The results indicate that the studied applications do not utilize these techniques and features nearly as well as they could. In general, less than 10 % of the possible behavior change techniques were used, and less than 15 % of the possible gamification features were used. This translates to 7,2 techniques and 5,9 features on average, per application. Even the application with most techniques and features utilized had 24 % and 43 % of them, respectively. Other studies have reached similar results. Direito and his colleagues (2014, 4) found on average 8,1 techniques in fitness and dietary applications out of 26 possible behavior change techniques, while Yang, Maher and Conroy (2014, 453) found on average 6,6 techniques out of 93 in applications for physical activity. Middelweerd and her colleagues (2014, 4) identified on average five behavior change technique from exercise applications out of 23. The differences in the total possible number of behavior change techniques are because different versions of this behavior change taxonomy have been available at different times.

The need to create better mobile applications has stood out from other research too. While studying theory, strategies and other content of mobile applications, Schoffman, Turner-McGrievy, Jones and Wilcox (2013, 322) found that over 60 % of the apps (n=57) for pediatric obesity prevention and treatment they analyzed contained no behavioral targets or recommended strategies. On average only 1,1 strategies was present out of the possible 15. Pagoto, Schneider, Jojic, DeBiasse and Mann (2013, 578) analyzed weight loss applications and found that on average 18,8 % of possible 20 behavioral strategies were reflected. All these numbers suggest the same; some techniques are being used, but there is clearly room for improvement. Hankonen and her colleagues (2015,14) found that the use of 11 or more behavior change techniques was correlated to successful weight loss so there are implications that sometimes more may be better.

In this thesis the main approaches found to change behavior were “self-monitoring of behavioral outcome(s)” by 100 %, “self-monitoring of behavior” by 75 %, “behavioral practice” and “goal setting outcome(s)” by 45 %, “habit formation” and “prompts/cues” by 40 %, “biofeedback” by 35 %, “information about health consequences” and “instruction on how to perform behavior” by 30 %, “goal setting (behavior)” by 25 % and “social support (unspecified)” by 20 %. “Social reward”, “social comparison” and “action planning” were present in only 15 % of the applications. Most often used behavior change techniques in other studies were providing feedback, self-monitoring and goal setting in applications for exercise (Middelweerd et al. 2014, 4); social support, information about others approval, instruction

on how to perform behavior, demonstration of behavior, feedback on behavior and goal setting (behavior) (Yang et al. 2014, 454) and provide instruction, set graded tasks, prompt self-monitoring of behavior, prompt identification as role model, plan social support and provide opportunities for social comparison (Direito et al. 2014, 4). All these other reviews were for fitness and diet related applications. Self-monitoring, information and instructions with goal setting seem to be among most popular techniques in all studies; however, social features are clearly more represented in the fitness and diet applications.

In other research focusing on the effectiveness of these techniques or similar strategies, there were good results from providing information about behavior and the health consequences, prompting follow-up, prompting intention formation (Dusseldorp et al. 2014, 1536), goal setting, reviewing goal, social support (Hankonen et al. 2015, 14) and using text messages, stress management, communication skills training, relapse prevention and social comparison (Webb et al. 2010). In the light of these results, the analyzed applications in this thesis and other research have adopted goal setting quite well and prompting follow-up to some extent. Some studies have adopted social support and social comparison. However, it is clear that the mobile applications focus too much on the information providing alone. It might be better to focus more on the possible behavior-health consequences link, creating clear intentions, providing social support and comparison in addition to reviewing and following the situation. In general, mobile applications can be recommended to support behavior change, if they are simple, interesting enough, suitable for everyday life and supporting small immediate actions in addition to being well updated and distributed properly (Kaipainen 2014, 5).

There were too few, less than six on average, gamification features in the mobile applications analyzed in this thesis to be able to assist in maintaining behavior change. It was clear that most of these applications were not initially designed for that. The features most often used were “context” by 100 %, “records of achievements” by 80 %, “interaction modes” by 65 %, “perceptuality” by 45 %, “best records” by 35 %, “guidance” by 35 % and “internal objectives” by 30 %. No other studies using the same taxonomy in health-related mobile application could be found, but other studies (e.g. Lister et al. 2014, 7) found similar features like levels of achievement. However, the usual features like rewards, leaderboards and social pressure were not present in a high degree in the applications studied in this thesis.

Gamification research is still new, and there are many opinions about it. The terms “gaming” and “gamification” still require research, especially considering what is effective in relation to health and health-related behavior. It is different to gamify something people want to do and something they do not want to do. It is also different to create health-related games than

it is to use gamifying to create good habits for everyday situations. Nevertheless, it has become clear that the roots of both behavior change and gamification are in psychology.

There is also a need for comprehensive gamification taxonomy. The gamification taxonomy used in this thesis was preliminary, as the authors stated themselves (Robinson & Bellotti 2013). This taxonomy is a very good starting point, but it still needs refining. Biggest problems while using it were similarities between different features, for example "records of achievements" consisting of many items like points, badges and checklists and "available game accomplishments" and "add to records of achievement". They all were in different general categories and could have therefore been counted perhaps many times. In the future, it would be good to see more detailed advice for using this taxonomy. The fine details may be very clear to gaming and gamification professionals but for outsiders more advice and refinement would be preferable.

Behavior change techniques and gamification features have proven to be good tools to use. The psychology behind both of them makes it easier for healthcare professional to understand, as the theories behind them intertwine with our theory base quite profoundly. However, as they originate from other research fields than ours, they have never crossed my professional path before. After using them in this thesis, I will certainly take advantage of them in my work in the future. There has been a certain lack of effective professional tools in guidance work, despite the use of motivational interviewing, which behavior change techniques fill. Therefore, I hope that many more healthcare professionals will find them and take advantage of them in their personal work and also while planning and evaluating interventions.

Sometime good tools are not used because it is too complicated to use them. That is the reason for the development of BC-TIP framework, which is an exemplary intervention lifecycle map using all the behavior change techniques presented by Michie and her colleagues (2013). This framework will provide visual guidance amongst the techniques making them easier to be used by professionals from various disciplines. All possible mistakes and misunderstandings of these techniques are mine. Even though the behavior change techniques have been around for quite a while, the new angle created in this thesis is the adaptation of them into the created intervention framework. As a healthcare professional, it is clear to me that I can utilize these techniques in a whole new way in my future work. This framework has also been discussed with the working life partner, a business owner who saw good potential in utilizing the framework in the future while developing mobile applications further. This can be interpreted as a weak market test.

An interesting resemblance was noticed after the framework was finished. The "everyday life" phase took close resemblance to Roy's adaptation model, a nursing theory developed by

Sister Callista Roy. In this theory a person is seen as a set of overlapping systems trying to adapt and maintain balance in the middle of various stimuli. People interact with their environment constantly, and process information through both cognitive and physiological mechanisms as well as through their identity and role function. The result is behavior, which is modified by all these aspects. (Vera 2014.)

The journey with this thesis has been long and winding but extremely rewarding. There are huge challenges in jumping out of your own sandbox, in my case nursing, and diving into the world of mobile applications, gamification, psychology and even service design. In spite of the expertise in the field of own profession, there is a whole new theory base to try to absorb in a fairly short time, and it is naturally not possible to master everything perfectly. However, in this thesis I have tried to broaden my own horizon as well as the horizon of the whole healthcare system. The world changes and healthcare must change with it. This thesis process has produced many ideas for future research. Naturally, the creation new mobile applications for chronic disease self-management, gamified applications and also interventions within healthcare using more behavior change techniques should be encouraged. There is a huge amount of health and fitness applications available. Even though they are much more popular than applications for chronic disease self-management, even they do not contain enough behavior change techniques, as discussed previously. They are, however, more entertaining and engaging. Chronic disease self-management will probably never be entertaining, but there is a desperate need for engaging mobile applications utilizing behavior change techniques in order to be really used. Usability and user experience gathering cannot be underlined enough in this process. Testing the usability of the BC-TIP framework in the creation of these applications and interventions would be interesting and in fact necessary, according to constructive research approach. And finally, the testing of well-developed mobile applications for their real efficacy in chronic disease management is needed.

Today's healthcare has already seen the movement of healthcare professionals out from the hospitals and healthcare centers into the pharmacies and shopping malls. That is where the patients use a big part of their time aside from their homes and workplaces. That is also where the "not yet" patients are, the consumers who hopefully will not become patients. Therefore, it is natural that health promotion and prevention, whether primary or secondary, happens there too. However, if we want to make a difference in a big scale, we must take promoting health where people use most of their time: the home and the workplace. In the future, when technology develops and becomes more affordable, there will be wearable and sensor technology, which will eventually be used for health-related purposes. Until that, there is only one solution already widely available in almost all age groups, the mobile phone or the tablet. Creating mobile applications may seem expensive at first, but considering the reach and transformability of best of them, the cost will even out to be very small during the

years. I hope that we as healthcare professionals will embrace new technology and be part of their development from the very beginning of the planning period. Only then will they be created by the healthcare standards and use all the good tools already used within healthcare and related fields.

Four years ago the headlines of major newspapers were screaming: “Chronic diseases will bankrupt the world by 2030!” The World Economic Forum and WHO had just released a report with calculations stating that from 2011 until 2030 with business as usual, the cost of chronic disease in the whole world will be 47 trillion dollars. It is unknown, whether this will really bankrupt the world but considering the amount of that money, it cannot be very far from it. In my opinion, those kinds of estimates tell that we are doing something wrong, and it is time to change direction. Maybe one of these directions is to implement digital health and mobile devices, like Topol and Fogg in the beginning were quoted. Change begins with small steps.

8.1 Limitations of this thesis

The scope of this research was intentionally focused on chronic diseases as a whole, and not to a specific disease like diabetes. Most chronic diseases share common risk factors and by focusing on those, a variety of chronic disease could be prevented or managed better so that they never proceed to a heart attack or a stroke. It is also very likely that people with multiple risk factors or multiple chronic diseases would rather use one, integrated mobile application than an application for each of these factors. However, also analyzing applications for a variety of specific diseases would naturally have produced more information.

Limitation of the study was that only applications from Apple iTunes were reviewed but not Android or Windows phone applications. The fact that applications downloaded were only from Finnish iTunes also diminishes the generalizability. There are also some mobile applications that are not publicly available for downloading. These are applications from certain healthcare providers or research organizations, and their usage is provided and controlled by the provider. It is possible and very likely that these applications may be more scientifically based and versatile. However, as it is impossible to download and test them, they are not part of this review.

An important limitation is also the very subjective perspective in the creation of this framework. It would definitely be much better if there would have been a team of different professionals creating it. The problem, however, was the fact that this behavior change techniques taxonomy is not known or utilized in Finnish healthcare to my knowledge, less alone amongst mobile application developers. Finding a willing organization and teaching these quite complex techniques would unfortunately not have been possible in the scope of this thesis pro-

cess. However, I consider myself a professional with a long history in the field of healthcare possessing also experience from the field of mobile application development. I believe that this gives me an expert position to have begun the creation of this framework. The semi-strong market testing of this construct in the future will undoubtedly provide more insights to the further development of this framework. Therefore, the weak testing of this framework only, naturally, is also a limitation of this thesis.

Even though behavior change techniques and BC-TIP framework can be used as one tool in mobile application development, alone they do not provide the guidelines for building digital health interventions. For that recommended reading can be found from Yardley, Morrison, Bradbury & Muller (2015). It should also be remembered, that all possible combinations of the behavior change techniques are not studied, and random combinations may not be as effective as well researched ones. A very recent accepted manuscript by Kok, Gottlieb, Peters, Dolan Mullen, Parcel, Ruiter, Fernández, Markham & Bartholomew (2015) acknowledges this, and presents a second behavior change taxonomy aimed more towards intervention development.

8.2 Trustworthiness and ethical aspects

The terms most often used in research to describe the trustworthiness are validity and reliability. Validity and reliability are traditionally used in quantitative research where validity for example is used to make sure that research is as objective, neutral, general, free of context, controlled, predicted and replicable as possible (Cohen, Manion & Morrison 2011). Validity also questions whether the used method measures, what it was supposed measure. In the content analysis of this thesis the purpose was to find out to what extent the available applications could be used to change behavior and maintain it. This was done by using well established behavior change taxonomy and a gamification taxonomy. To my understanding the method was right for fulfilling the research questions. The replicability in studying mobile applications cannot be achieved, as there are constantly new versions of them provided.

Cohen and his colleagues (2011) also describe reliability as demonstrability, stability, coverage of domain, verification of data and analysis, consistency and neutrality; just to name a few. All possible measures were taken to secure the reliability of this thesis. Thorough explanations of the steps taken during the thesis process have been provided with figures. However, considering the content analysis, subjectivity was naturally present. Both taxonomies leave room for interpretation, therefore in addition to statistics also figures were provided for the explanation of some interpretations. I originally participated in an online training course of BCT Taxonomy by University College London (UCL) England. This was done to ensure that the coding of the techniques were as correct as possible.

From a methodological point of view qualitative and quantitative research are different. Every science has its own ontological and epistemological foundations so they should always be taken into account. This is also what needs to be done while contemplating the trustworthiness of qualitative research. Golafshani (2003, 600) refers to Hoepfl (1997) while citing qualitative researchers seeking "illumination, understanding, and extrapolation to similar situations". Trustworthiness in qualitative research is often described by referring to Lincoln and Guba (1985) who state that trustworthiness is to support the argument that the findings are "worth paying attention to" (Elo, Kääriäinen, Kanste, Pölkki, Utriainen & Kyngäs 2014, 2). The authors remind that trustworthiness has to be present from the beginning of the research to the end of it.

Today, according to previously mentioned Lincoln and Guba, the more often used terms for defining trustworthiness of qualitative research are credibility, dependability, confirmability, transferability and authenticity (Elo et al. 2014, 2). Some of the methods for building credibility are accurate identification and description of participants. Dependability can be improved by opening the decision trail, discussing subjectivity, the decisions made about theory, analytics and methods and following the accepted standards. Confirmability can be verified by presenting the raw data, development of the methods and findings, data sources and early intentions of the research. Transferability can be seen as opening sampling in order to see how and why the informants have been chosen and has the sampling been representative enough to be maybe generalized and transferred to other sample. (Laurea 2013.) In literature authenticity is sometimes described as a trustworthiness issue (Elo et al. 2014, 2), sometimes not. Authenticity can be understood by the means to achieve qualitative research ends. (Silverman 2011, 44.)

These aspects were all kept in mind in the thesis process. Credibility and dependability were pursued by providing background, presenting the importance of the subject and presenting the "whys". The development of the new framework was a very subjective process. However, the raw material for that, the behavior change techniques, is the work of completely other researchers. Plenty of raw data was provided and development of findings was opened. The search process for the mobile applications that were "informants" in this thesis has been described. Whether part of trustworthiness or not, this thesis provides authentic and novel perspective to one of the most interesting phase of modern healthcare; the digital healthcare.

From the methodological perspective one step of the constructive approach, stronger testing of the construct that was developed was not included in this thesis. Due to the explicit nature of the behavior change techniques, it was not within the scope or the possibilities of this thesis to test the new construct, BC-TIP framework, with semi-strong or strong testing. Hopefully, it will be found by both the mobile application developers and healthcare

professionals so that the testing will be a real “market test”. The construct, BC-TIP, serves as a tool to make the behavior change techniques more visible and more understandable. It also provides a new perspective, the timeline, which combined with the behavior change techniques, constitutes a new framework. This framework will act as a tool in real life use and also relates to theory, as discussed before.

Cunningham et al. (2013, 35) summarized ethical starting points of a research process pointing out aspects of competence in research team, proper research design and proper data management. Qualitative research is always subjective in some way. The researcher has to be aware of her attitudes and be open about them. This is especially true while analyzing the data; subjectivity is always present. Kumar (2012, 246) differentiates subjectivity from bias. He illustrates bias as a deliberate attempt to hide something or to highlight something too much and as such unethical. The subjectivity of this thesis process has been discussed earlier and it has been kept in mind during the whole process. Therefore large parts of the process have been opened in this work. The research design was thoroughly considered and all data was carefully handled. As there were no human informants involved in this thesis, no ethical approvals or research licenses were necessary.

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Figures

Tables

Appendices

Appendix 1: Behavior Change Technique (BCT) Taxonomy by Michie et al. 2013

1 Goals and planning
1.1 Goal setting (behavior)
1.2 Problem solving
1.3 Goal setting (outcome)
1.4 Action planning
1.5 Review behavior goal(s)
1.6 Discrepancy btw current behavior and goal
1.7 Review outcome goal(s)
1.8 Behavioral contract
1.9 Commitment

2 Feedback and monitoring
2.1 Monitoring of behavior by others without feedback
2.2 Feedback on behavior
2.3 Self-monitoring of behavior
2.4 Self-monitoring of outcome(s) of behavior
2.5 Monitoring of outcome(s) of behavior without feedback
2.6 Biofeedback
2.7 Feedback on outcome(s) of behavior

3 Social support
3.1 Social support (unspecified)
3.2 Social support (practical)
3.3 Social support (emotional)

4 Shaping knowledge
4.1 Instruction on how to perform the behavior
4.2 Information about antecedents
4.3 Re-attribution
4.4 Behavioral experiments

5 Natural consequences
5.1 Information about health consequences
5.2 Salience of consequences
5.3 Information about social and environmental consequenc-
es
5.4 Monitoring of emotional consequences
5.5 Anticipated regret
5.6 Information about emotional consequences

6 Comparison of behavior
6.1 Demonstration of the behavior
6.2 Social comparison

6.3 Information about others approval

7 Associations
7.1 Prompts/cues
7.2 Cue signalling reward
7.3 Reduce prompts/cues
7.4 Remove access to the reward
7.5 Remove aversive stimulus
7.6 Satiation
7.7 Exposure
7.8 Associative learning

8 Repetition and Substitution
8.1 Behavioral practice/rehearsal
8.2 Behavioral substitution
8.3 Habit formation
8.4 Habit reversal
8.5 Overcorrection
8.6 Generalisation of target behavior
8.7 Graded tasks

9 Comparison of outcomes
9.1 Credible source
9.2 Pros and cons
9.3 Comparative imagining of future outcomes

10 Reward and threat
10.1 Material incentive (behavior)
10.2 Material reward (behavior)
10.3 Non-specific reward
10.4 Social reward
10.5 Social incentive
10.6 Non-specific incentive
10.7 Self-incentive
10.8 Incentive (outcome)
10.9 Self-reward
10.10 Reward (outcome)
10.11 Future punishment

11 Regulation
11.1 Pharmacological support
11.2 Reduce negative emotions
11.3 Conserving mental resources
11.4 Paradoxical instructions

12 Antecedents
12.1 Restructuring the physical environment
12.2 Restructuring the social environment
12.3 Avoidance/reducing exposure to cues for the behavior
12.4 Distraction
12.5 Adding objects to the environment
12.6 Body changes

13 Identity
13.1 Identification of self as role model
13.2 Framing/deframing
13.3 Incompatible beliefs
13.4 Valued self-identify
13.5 Identity associated with changed behavior

14 Scheduled consequences
14.1 Behavior cost
14.2 Punishment
14.3 Remove reward
14.4 Reward approximation
14.5 Rewarding completion
14.6 Situation-specific reward
14.7 Reward incompatible behavior
14.8 Reward alternative behavior
14.9 Reduce reward frequency
14.10 Remove punishment

15 Self-belief
15.1 Verbal persuasion about capability
15.2 Mental rehearsal of successful performance
15.3 Focus on past success
15.4 Self-talk

16 Covert learning
16.1 Imaginary punishment
16.2 Imaginary reward
16.3 Vicarious consequences

Appendix 2: Taxonomy of Gamification, framework details (Robinson & Bellotti 2013)

Element	Code	Rationale
General Framing		
Context	L	Context is always salient for whether someone is likely to invest time and effort.
Background	M/H	Time taken to absorb background may be too high to bother in low commitment context.
Narrative	M/H	See above.
General Rules and Performance Framing		
Guidance	L/M	Lightweight guidance can be carefully designed.
Internal Objectives	L	Simple objective / target can be explained by an image or short sentence.
Ambiguous Path to Objective	M/H	Puzzles need some commitment to be effective. Good puzzles may require a lot of engagement.
Renewal/ Regeneration	M	Requires some commitment to return. Wouldn't work for one-off or rare visits.
Set for Completion	L	Even a small set can be effective, so OK for low commitment.
Notable Records of Achievements	L	Easy to read things like "High Score=1035" so OK for low commitment settings.
Social Features		
Relationships	L/M	Usually requires higher commitment. Possible to apply with preexisting social vectors.
Interaction Modes	L/M	See above.
Visibility/ Accountability	L/M	See above.
Social Performance	L/M	See above.

Element	Code	Rationale
Intrinsic Incentives		
Curiosity	L	Curiosity can be triggered quickly and leads to higher engagement/commitment.
Challenge	L	Simple challenges can be effective even in a low commitment setting.
Entertainment	L	Simple elements can work very quickly in low commitment settings.
Social Reward / Peer Pressure	V	In low commitment setting you depend on the context to create a social vector.
Personal Returns	V	Without context, significant explaining may be necessary for some returns.
Societal Returns	V	See above.
Extrinsic Incentives		
Deals / Discounts	L	Easily understood. Can be designed with complete control.
Financial	L	See above.
Goods / Services	L	See above.
Time	L	See above.
Lottery / Draw / Bet	L	See above.
Virtual Currency / Goods	H	Only works if user is committed enough to use it.
Virtual Abilities	H	See above.
Add to Record of Achievements	M	Can work as long as the user can be made to value personal or public record.
Validation	M	See above.

Element	Code	Rationale
Resources and Constraints		
Available Game Accomplish-ments	L	All gameful experiences require something to do or accomplish.
Control Repertoire	L	All gameful experiences involve a means to control actions.
Choice Architecture	L	Easy to implement even in the simplest experience.
Specific Rules	L	Gamified experiences all require specific rules, otherwise they are just play.
Scarcity of Resources	L/M	Perhaps possible to design into low commitment games.
Temporal Aspects	L	Time-based elements are easily incorporated in low commitment settings.
Perceptual Aspects	L	Any gamified experience requires perceptual elements even if only sound
Topological Aspects	L/M	Possible but difficult to design good topological elements for low commitment situations.
Ability, Difficulty and Advanceme-nt	M	Requires commitment to confer a sense of increasing ability.
Change / Novelty	M	Difficult to design novel experiences in low commitment experiences.
Feedback and Status Information		
Graphical Indicators	L	Easy to design, and in fact critical for all gamification.
Audio Signals	L	Easy to design and often helpful for gamification.
Records of Achievement s	L	Easy to design and possibly essential in gamification.
Updated Context	L	Simple context devices can be used even in low commitment settings.

Appendix 3: Mobile applications analyzed in this thesis

Name	**Version**	Behavior change techniques n=93 (%)	Gamification features n=42 (%)	Measurements n=22 (%)	General characteristics n=10 (%)
Symptom and lab value manager	1.0.3	2 (2,2)	4 (9,5)	12 (54,5)	3 (30)
TracknShare LITE	6.4.3	5 (5,4)	6 (14,3)	10 (45,5)	7 (70)
Activ8rlives 3.0 Health Monitoring and Food Diary App	3.0.5	15 (16,1)	12 (28,6)	15 (68,2)	4 (40)
Health Diary	2.1.0	2 (2,2)	3 (7,1)	9 (40,9)	6 (60)
HealthMoments - A health diary	1.0	2 (2,2)	7 (16,7)	18 (81,8)	3 (30)
Health mate	2.5.0	22 (23,7)	18 (42,9)	7 (31,8)	9 (90)
HealthWatch 360	1.5	13 (14)	9 (21,4)	9 (40,9)	5 (50)
Health Tracker & Manager	2.1	1 (1,1)	2 (4,8)	7 (31,8)	4 (40)
MyHealth Tracker	1.1	2 (2,2)	1 (2,4)	10 (45,5)	0 (0)
My Crittenton Health Tracker	1.3	16 (17,2)	6 (14,3)	2 (9,1)	5 (50)
Qualia Plus - Health score and tracker	1.0	4 (4,3)	7 (16,7)	9 (40,9)	1 (10)
HealthTracker and Manager by Constant MD	1.0.5	5 (5,4)	6 (14,3)	15 (68,2)	4 (40)
LightArrow My.Self	1.3.3	7 (7,5)	5 (11,9)	14 (63,6)	6 (60)
AT Health Tracker	1.0	1 (1,1)	1 (2,4)	5 (22,7)	0 (0)
EZ Health Tracker	2.1	2 (2,2)	2 (4,8)	8 (36,4)	1 (10)
Health Mapper	1.2.5	6 (6,5)	4 (9,5)	17 (77,3)	6 (60)
TactioHealth	6.1	14 (15,1)	7 (16,7)	14 (63,6)	10 (100)
Personal health record lite	1.0	1 (1,1)	2 (4,8)	9 (40,9)	1 (10)
Parrish medical center HealthBridge	4.6	10 (10,8)	4 (9,5)	14 (63,6)	6 (60)
BodyWise - Health & Fitness Tracker	2.4.1	14 (15,1)	11 (26,2)	8 (36,4)	2 (20)
MEAN		7,2 (7,8)	5,9 (14)	10,6 (48,2)	4,1 (41,5)